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会议议程

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美国贸易开发署（USTDA）
中国-美国标准与合格评定合作项目（SCACP）
第五届静电防护与标准化国际研讨会

会议议程

时间、地点:

2016 年 11 月 17 日
西安天宇菲尔德大酒店 • 西安
中国陕西省西安市航天经济技术开发区神舟三路 239 号

主办单位:

中国标准化研究院
中国空间技术研究院
电磁环境效应国家级重点实验室
美国贸易开发署（USTDA）
美国国家标准协会（ANSI）
美国静电放电协会（ESDA）

协办单位:

中国电子仪器行业协会防静电装备分会
上海防静电工业协会
北京电子仪器行业协会
国防科技工业火炸药一级计量站
四川航天计量测试研究所
山东电盾科技股份有限公司
上海佰斯特电子工程有限公司
一远静电科技有限公司
北京谱脉技术有限责任公司
山东中电陶瓷有限公司

承办单位:

北京东方计量测试研究所
中国标准化杂志社
西安空间无线电技术研究所

2016 年 11 月 17 日

08:00 - 09:00　报到注册

09:00 - 09:30　致欢迎辞

09:30 - 10:00　报告题目 1：静电危害及防护

演讲专家：刘尚合，中国工程院院士

电磁环境效应国家级重点实验室

10:00 - 10:25　报告题目 2：标准化作用的再认识

演讲专家：汤万金，研究员，副院长

中国标准化研究院

10:25 - 10:45　茶歇，合影

10:45 - 11:15　报告题目 3：静电放电控制过程评估

演讲专家：John T. Kinnear Jr，公司董事，专业认证主席

IBM

11:15 - 11:40　报告题目 4：纳米集成电路静电冲击防护介绍

演讲专家：董树荣，教授，副所长

浙江大学微电子所

11:40 - 12:05　报告题目 5：ESD 防护标准与中国电子制造企业的防护工程实际

演讲专家：来萍，研究员

工信部第五研究所

12:05 - 12:20　现场互动交流

12:20 - 13:30　午餐

13:30 - 13:55　报告题目 6：国家标准 GB/T 32304《航天电子产品静电防护要求》解读与应用

演讲专家：刘民， 研究员，总工程师

北京东方计量测试研究所，北京电子仪器行业协会

13:55 - 14:25　报告题目 7：如何面对超敏感静电产品的静电防护

演讲专家：Terry L. Welsher，荣誉主席

Dangelmayer 联合有限责任公司

14:25 - 14:50 **报告题目 8：静电放电的电极移动速度效应研究和非接触静电放电标准问题初探**

演讲专家：阮方鸣，教授

贵州师范大学

14:50 - 15:10 **现场互动交流**

15:10 - 15:30 **茶歇**

15:30 - 16:00 **报告题目 9：自动化生产线中的设备受到CDM作用的情况分析**

演讲专家：Reinhold Gaertner，公司董事，制造业研讨会业务部经理

Infineon 科技

16:00 - 16:25 **报告题目 10：石化企业静电风险及防护**

演讲专家：李义鹏，高级工程师

中国石化安全工程研究院

16:25 - 16:50 **报告题目11：T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读**

演讲专家：黄建华，理事长

上海防静电工业协会

16:50 - 17:10 **现场互动交流**

会议结束

U.S.-China Standards and Conformity Assessment Cooperation Program (SCACP)
The United States Trade and Development Agency (USTDA)

The 5th Electrostatic Protection and Standardization International Conference

Agenda

Date/Venue:

November 17, 2016
Xi'an TianYu Field International Hotel·XI'AN
No.239, 3rd Shenzhou Rd, Aerospace Economic and Technological Development Zone, Xi'an.

Sponsors:

China National Institute of Standardization (CNIS)
China Academy of Space Technology (CAST)
National Key Laboratory for Electromagnetic Environmental Effects
The United States Trade and Development Agency (USTDA)
American National Standards Institute (ANSI)
Electrostatic Discharge Association (ESDA)

Co-organizers:

China's Electronic Instrument Industry Association Anti-static Equipment Branch
Shanghai Electrostatic Protective Industrial Association
Beijing Electronic Instrument Industry Association
Primary Standard of Laboratory of Explosives and Powders, COSTIND
Sichuan Aerospace Institute of Measurement and Test
Shandong Diandun Science and Technology Holdings Co., Ltd
Shanghai POUSTO Electronic Engineering Co.,Ltd
YIYUAN Electronic Technology Co, Ltd
Beijing ProMax Technologies, Inc
Shandong Zhongdian Ceramics Co., Ltd

Organizers:

Beijing Orient Institute of Measurement and Test
China Standardization Press
Academy of Space Electronic Information Technology

November 17, 2016

08:00 - 09:00 **Registration**

09:00 - 09:30 **Welcome Address**

09:30 - 10:00 **Topic 1: The Hazard and Protection of Electrostatic**

Speaker: Liu Shanghe, Academician of Chinese Academy of Engineering

National Key Laboratory for Electromagnetic Environmental Effects

10:00 - 10:25 **Topic 2: Re-recognition of Standardization Effect**

Speaker: Tang Wanjin, Researcher, Vice Director

China National Institute of Standardization

10:25 - 10:45 **Coffee break**

10:45 - 11:15 **Topic 3: Process Assessment**

Speaker: John T. Kinnear Jr., BoD of Directors, Professioanl Certifcation Chair

IBM

11:15 - 11:40 **Topic 4: ESD Protection in Nanometer CMOS Process**

Speaker: Dong Shurong, Professor

Microelectronics and Nano-electronics Institute of Zhejiang University

11:40 - 12:05 **Topic 5: Plant-level ESD Standards in China's Electronics Manufacturing Industry**

Speaker: Lai Ping, Researcher

The 5th Electronics Research Institute of Ministry of Industry and Information Technology

12:05 - 12:20 **Interactive Communication**

12:20 - 13:30 **Lunch**

13:30 - 13:55 **Topic 6: Interpretation and Application about National Standard GB/T 32304 *Electrostatic discharge protection requirements for aerospace electronic products***

Speaker: Liu Min, Researcher, Chief Engineer

Beijing Orient Institute of Measurement and Test, CAST

Beijing Electronic Instrument Industry Association

13:55 - 14:25 **Topic 7: Facing the Challenge of Electrostatic Protection of Ultra-Sensitive Devices**

Speaker: Terry L. Welsher , President Emeritus

Dangelmayer Associates, LLC

14:25 - 14:50 **Topic 8: Investigation of Electrode Moving Speed Effect in Electrostatic Discharge Involved in Standard on Non-Contact ESD**

Speaker: Ruan Fangming, Professor

Guizhou Normal University

14:50 - 15:10 **Interactive Communication**

15:10 - 15:30 **Coffee break**

15:30 - 16:00 **Topic 9: What CDM stress does a device see in an automated production line**

Speaker: Reinhold Gaertner, BoD of Dirctors, Manufacturing Sympoium Busioness Unit Manager

Infineon Technologies

16:00 - 16:25 **Topic 10: Electrostatic Risk and Protection of Petrochemical Enterprise**

Speaker: Li Yipeng, Senior Engineer

Sinopec Safety Engineering Institute

16:25 - 16:50 **Topic 11: Interpretation of T/ESD001-2016 Static Control Garment for Electronic Industry - General Technical Regulations**

Speaker: Huang Jianhua, Chairman

Shanghai Electrostatic Protective Industrial Association

16:50 - 17:10 **Interactive Communication**

The End

主办、协办及承办单位介绍

Sponsor and Organizer Overviews

中国标准化研究院

中国标准化研究院（初名国家科委标准化综合研究所）始建于 1963 年，是直属于国家质量监督检验检疫总局，从事标准化研究的国家级社会公益类科研机构，主要针对我国国民经济和社会发展中全局性、战略性和综合性的标准化问题进行研究。

全院现有职工 500 余人，包括研究员 27 名、博士及博士后 87 名，主要开展标准化发展战略、基础理论、原理方法和标准体系研究。承担节能减排、质量管理、公共安全、视觉健康与安全防护、现代服务、公共管理与政务信息化、信息分类编码、人类工效、食品感官分析等领域标准化研究及相关标准的制修订工作。承担相关领域的全国专业标准化技术委员会、分技术委员会秘书处工作。承担相关标准科学实验、测试等研发及科研成果的推广与应用工作。组织开展能效标识、顾客满意度测评工作，承担地理标志产品保护研究及技术支持工作。负责标准文献资源建设与社会化服务工作，承担国家标准文献共享服务平台运行和标准化基础科学数据资源建设与应用工作。同时，我院的工作直接支撑着国家质量监督检验检疫总局以及国家标准化管理委员会的相关管理职能，包括我国缺陷产品召回管理、国家标准技术审查、全国工业产品生产许可证审查、全国质检中心审查管理等工作。

作为国家级社会公益类科研机构，中国标准化研究院一直致力于积极参与并主导国际组织活动，维护国家利益，承担了国际地理标志网络组织（ORIGIN）副主席职务，承担了国际标准化组织(ISO)的技术委员会副主席、秘书等 13 个关键职务，主持制定 ISO 标准 20 余项。

地址：北京市海淀区知春路 4 号

邮编：100088

http://www.cnis.gov.cn

China National Institute of Standardization

Affiliated with the General Administration of Quality Supervision and Inspection and Quarantine of the People's Republic of China (AQSIQ), China National Institute of Standardization (CNIS) is a non-profit national research body engaging in standardization research. The main responsibilities of CNIS are to conduct all-round, strategic, and comprehensive research of standardization during the development process of economy and society, to research and develop comprehensive fundamental standards, as well as to provide authoritative standards information services. CNIS is poised to provide all-round support in standardization for China's economic development and social progress, to support technical progress, industrial upgrading, and product's quality improvement, and to provide scientific evidence for government policy-making on standardization.

Since its founding in 1963, CNIS has undertaken many national key scientific and research projects. Among them, three important projects of the 10th Five-Year Plan (2000-2005) Key Science and Technology Special Program, namely, Research on Development Strategies for Chinese Technical Standards, Research on Development of China's National Technical Standards System, and Basic Research on and Technological Measures for the Safety Standards of Main Foods, have played important supportive roles for promotion of national standardization. One of our projects, Development of a National Terminology and Graphic Symbol System, has been awarded the State-level Second Prize for Advancement of Science and Technology, the highest prize so far in the field of scientific research on standardization. In addition, many of our projects have been awarded state-level and ministry-level prizes for advancement of science and technology and prizes for key scientific research achievements of the 8th (1990-1995), and 9th (1995-2000) Five-Year Plan periods. Our research has brought about significant influence home and abroad, and has made outstanding contributions to development of China's economic development and the progress of science and technology.

Address：No.4 Zhichun Road, Haidian District, Beijing

Post code：100088

http://www.cnis.gov.cn

中国空间技术研究院

中国空间技术研究院成立于 1968 年，隶属中国航天科技集团公司。经过 40 余年的发展，中国空间技术研究院已成为中国主要的空间技术及其产品研制基地，是中国空间事业最具实力的骨干力量，主要从事空间技术开发、航天器研制，空间领域对外技术交流与合作、航天技术应用等业务。

自 1970 年，中国空间技术研究院先后成功研制并发射了中国第一颗人造地球卫星——东方红一号、实现环月运行的中国首颗月球探测器、实现中国航天员首次空间出舱活动的神舟七号载人飞船等，为中国航天事业发展做出了突出贡献。中国空间技术研究院在北京航天城建成了集系统设计与集成、总装、测试、试验一体化的新型航天器研制生产基地，现在拥有员工 1 万余人，其中包括 8 名两院院士、12 名国家级突出贡献专家和 1700 多名高级专业技术人才。

中国空间技术研究院是我国飞船和卫星的重点研制单位，十分重视电子元器件、单机及整机系统的电磁兼容设计，开展了大量的地面和星上静电防护技术研究工作，并在静电防护管理体系、静电防护技术、防静电系统测试、防静电工作区配置等方面建立了一系列的静电防护院级标准 Q/W 1300~1303-2010，组建了院静电防护管理体系认证委员会和认证中心，在认证中心办公室和审核专家组的协助下，明确了静电防护系统建设与认证管理流程，已经完成对多家院内单位及外协单位开展了静电防护管理体系认证工作，推进了航天领域的静电安全防护进程。

China Academy of Space Technology (CAST)

China Academy of Space Technology (CAST), subordinated to China Aerospace Science and Technology Corporation (CASC), was established on February 20, 1968. Through 44-year development, it has become the main development base for space technology and products in China and the most powerful backbone strength for China's space endeavor. It is mainly engaged in such fields as development and manufacturing of spacecraft, external exchange and cooperation in space technology, satellite applications, etc. CAST also participates in formulating the state space technology development plans, studies the technological approaches to exploration, exploitation and utilization of outer space, and develops a variety of spacecraft and ground application equipments.

CAST successfully developed and launched china's first artificial earth satellite. To date, the academy has successfully developed and launched 129 satellites of various kinds and nine Shenzhou spaceships, including scientific and technological test satellites, communications and broadcasting satellites, meteorological satellites, returnable remote sensing satellites and ocean satellites.

CAST has built in Beijing Space City a new spacecraft development and production base which combines system design, assembly, integration, checkout and test in one place. CAST has more than 20,000 staff members, including 8 members of Chinese Academy of Sciences and Chinese Academy of Engineering, 12 national level experts making outstanding contributions, and over 1700 senior specialists. CAST has been making wide contacts with the astronautical companies and space research institutes throughout over a dozen countries and regions.

CAST has engaged in electrostatic field of development of spacecraft and ground application equipments for years, and published series of standards for electrostatic discharge protection management system. It has established certification committee and Electrostatic Discharge Certification of the system, and organized the electrostatic certification of units subordinated to CAST and other co-operation units.

美国贸易开发署（USTDA）

由美国贸易发展署 (USTDA) 提供资助、 美国国家标准协会 (ANSI) 负责协调的美中标准与合格评定合作项目(SCCP) 在以下几个方面为美国和中国相关行业和政府代表提供了一个论坛：

1. 在标准、合格评定以及技术法规等领域的合作;

2. 为促进美中在标准、合格评定以及技术法规等领域的技术交流建立必要的联系;

3. 及时交流关于标准、合格评定以及技术法规等领域的最新议题和发展情况的相关信息

根据 SCCP 项目规定，从 2013 年开始的三年内，ANSI 将在中国协调举办 20 场研讨会。根据美国私营业界相关组织的建议，研讨会内容将覆盖不同的行业和领域。

研讨会的主题将由相关行业组织、ANSI 以及 USTDA 协调选定。

欲了解该项目的更多情况或有意赞助或参与该项目，请访问下列网站：

www.standardsportal.org/us-chinasccp

U.S. Trade and Development Agency

The U.S. Trade and Development Agency (USTDA) helps companies create U.S. jobs through the export of U.S. goods and services for priority development projects in emerging economies. USTDA links U.S. businesses to export opportunities by funding project planning activities, pilot projects, and reverse trade missions while creating sustainable infrastructure and economic growth in partner countries.

美国国家标准学会

American National Standards Institute（ANSI——美国国家标准学会）是由公司、政府和其他成员组成的自愿组织，负责协商与标准有关的活动，审议美国国家标准，并努力提高美国在国际标准化组织中的地位。ANSI 是 IEC 和 ISO 的 5 个常任理事成员之一，也是 4 个理事局成员之一，参加 79%的 ISO/TC 的活动，参加 89%的 IEC/TC 活动。ANSI 是泛美技术标准委员会（COPANT）和太平洋地区标准会议（PASC）的成员。

美国国家标准学会（American National Standards Institute: ANSI）成立于 1918 年。当时，美国的许多企业和专业技术团体，已开始了标准化工作，但因彼此间没有协调，存在不少矛盾和问题。为了进一步提高效率，数百个科技学会、协会组织和团体，均认为有必要成立一个专门的标准化机构，并制订统一的通用标准。1918 年，美国材料试验协会（ASTM）、与美国机械工程师协会（ASME）、美国矿业与冶金工程师协会（ASMME）、美国土木工程师协会（ASCE）、美国电气工程师协会（AIEE）等组织，共同成立了美国工程标准委员会（AESC）。美国政府的三个部（商务部、陆军部、海军部）也参与了该委员会的筹备工作。1928 年，美国工程标准委员会改组为美国标准学会（ASA）。为致力于国际标准化事业和消费品方面的标准化，1966 年 8 月，又改组为美利坚合众国标准学会（USASI）。1969 年 10 月 6 日改成现名：美国国家标准学会（ANSI）。

美国国家标准学会是非赢利性质的民间标准化组织，是美国国家标准化活动的中心，许多美国标准化学协会的标准制修订都同它进行联合，ANSI 批准标准成为美国国家标准，但它本身不制定标准，标准是由相应的标准化团体和技术团体及行业协会和自愿将标准送交给 ANSI 批准的组织来制定，同时 ANSI 起到了联邦政府和民间的标准系统之间的协调作用，指导全国标准化活动，ANSI 遵循自愿性、公开性、透明性、协商一致性的原则，采用 3 种方式制定、审批 ANSI 标准。

ANSI 现有工业学、协会等团体会员约 200 个，公司（企业）会员约 1400 个。领导机构是由主席、副主席及 50 名高级业务代表组成的董事会，行使领导权。董事会闭会期间，由执行委员会行使职权，执行委员会下设标准评审委员会，由 15 人组成。总部设在纽约，卫星办公室设在华盛顿。

American National Standards Institute (ANSI)

As the voice of the U.S. standards and conformity assessment system, the American National Standards Institute (ANSI) empowers its members and constituents to strengthen the U.S. marketplace position in the global economy while helping to assure the safety and health of consumers and the protection of the environment.

The Institute oversees the creation, promulgation and use of thousands of norms and guidelines that directly impact businesses in nearly every sector: from acoustical devices to construction equipment, from dairy and livestock production to energy distribution, and many more. ANSI is also actively engaged in accrediting programs that assess conformance to standards – including globally-recognized cross-sector programs such as the ISO 9000 (quality) and ISO 14000 (environmental) management systems.

ANSI has served in its capacity as administrator and coordinator of the United States private sector voluntary standardization system for more than 90 years. Founded in 1918 by five engineering societies and three government agencies, the Institute remains a private, nonprofit membership organization supported by a diverse constituency of private and public sector organizations.

Throughout its history, ANSI has maintained as its primary goal the enhancement of global competitiveness of U.S. business and the American quality of life by promoting and facilitating voluntary consensus standards and conformity assessment systems and promoting their integrity. The Institute represents the interests of its nearly 1,000 companies, organization, government agency, institutional and international members through its office in New York City, and its headquarters in Washington, D.C.

美国静电放电协会

Electrostatic Discharge Association（ESDA——美国静电放电协会）于 1982 年在美国成立，总部设在纽约，是一个专业的自愿组织，从事静电放电理论和实践研究。其成员从成立初期不到 100 名，发展到遍布全球、总数超过 2,000 名。其领域从仅限于电子元器件的 ESD 影响，拓宽到纺织品、塑料、居室清洁和形象艺术等领域。该协会授权通过标准开发、教育节目、专业书籍、出版物、指南、认证工作和座谈会宣传 ESD 知识。

ESDA 是一个国际化组织，其成员来自 30 多个国家。他们服务于协会标准委员会，在 EOS/ESD 年会上进行技术研讨，并为其它国家的相关组织提供资讯联系。协会已经和不同国家的类似组织建立了正式和非正式联系，正式联系包括日本可靠性中心，新加坡生产力标准部（PSB），日本电子工业协会（EIAJ），德国 ESD 论坛，欧洲的 ESREF，以及巴西的 ABRICEM。

ESDA 的职责是在国际电工委员会（IEC）静电学领域代表美国利益。随着标准领域全球协调性要求的增加，ESD 协会日益受到广泛关注。

Electrostatic Discharge Association (ESDA）

Founded in 1982, the ESD Association (ESDA) is a professional voluntary association dedicated to advancing the theory and practice of electrostatic discharge (ESD) avoidance. From fewer than 100 members, the Association has grown to more than 2,000 members throughout the world. From an initial emphasis on the effects of ESD on electronic components, the Association has broadened its horizons to include areas such as textiles, plastics, web processing, clean-rooms, and graphic arts. To meet the needs of a continually changing environment, the Association is chartered to expand ESD awareness through standards development, educational programs, local chapters, publications, tutorials, certification, and symposia.

Although founded and headquartered in the United States, the ESD Association has a strong international flavor. Its members come from more than 30 countries throughout the world. They serve on Association Standards Committees, present technical papers at the annual EOS/ESD Symposium, and provide the communication links with similar organizations in other countries.

The Association has established informal and formal relationships with similar organizations in various countries. The formal relationships include the Reliability Center of Japan, Productivity Standards Board (PSB) in Singapore, Electronics Industry Association of Japan (EIAJ), ESD Forum of Germany, ESREF in Europe, and ABRICEM in Brazil.

The ESD Association has the responsibility of representing the interest of the United States at the International Electro-technical Commission (IEC) in the area of electrostatics. With the increasing need for global harmonization in the area of standards, the international focus of the ESD Association is vitally important.

中国电子仪器行业协会防静电装备分会

中国电子仪器行业协会防静电装备分会成立于一九九七年。业务上受国家工业和信息化部相关部门的指导，隶属于中国电子仪器行业协会。是由从事静电与净化控制产业研发、制造、销售、工程施工、检测、培训及应用的相关企事业单位、大专院校、科研院所、业内有关社会团体，以及专家、学者等热心静电与净化控制事业的个人，不受部门和地区限制，自愿组成的全国非盈利性社会团体。本协会经国家民政部批准依法登记，具有社会团体法人资格的社会组织，现有会员单位 280 余家。

协会的宗旨是：为会员单位服务，维护本行业和会员单位的合法权益，贯彻执行国家的政策法律法规，推动防静电装备行业的发展。

防静电装备分会的主要任务包括：

1、协助政府部门制定本行业的技术与产业发展规划；

2、组织行业内外有关单位的联合技术攻关和开发新产品；

3、征集会员单位建议，向政府有关部门反映、沟通情况；

4、组织行业概况调研，制定行规行约；

5、组织并参与制、修定本行业的 GB、GJB、SJ/T 等标准工作；

6、开展技术研究、产品开发、投资项目的论证、评估等咨询服务；

7、开展本行业经营管理业务的培训；

8、利用协会网站组织防静电技术及应用的推广普及，开展市场调研，协助会员单位开拓市场、沟通生产单位与用户之间的联系；

9、开展与国内外有关学术团体、企事业单位、行业协会、信息网及杂志社等联系与合作，组织技术、产品及应用市场等方面的交流，组织国内国际展览会、展示会和技术研讨会等；

10、出版行业刊物《中国防静电》杂志，向政府部门、会员单位、相关用户免费赠阅；

11、根据政府部门委托和会员单位要求，举办其他有关活动。

联系方式：（010）68647410/51246352（电话）（010）68647410（传真），北京市石景山区万达广场 CRD 银座 B-1128 室，100040。网站为 66 防静电网，邮箱 chinaesd@chinaesd.org.cn

China's Electronic Instrument Industry Association

Anti-static Equipment Branch

Anti-static equipment branch is the anti-static equipment industry engaged in scientific research, production and management of enterprises and institutions, not affected by departments and regions limit is composed of voluntary social organizations. Belongs to the Chinese electronic instrument industry association, the association the approval of the ministry of civil affairs shall be registered according to law, have the corporative qualifications of social group, more than 280 members of the existing units.

Association's objective is: for the member unit service and maintain the industry member unit and the lawful rights and interests of the implement state policy laws and regulations, and promote the development of anti-static equipment industry.

Anti-static equipment branch is the government department of anti-static equipment industry to industry management assistant and staff. In the government department and the enterprises and institutions between the bridge and button take effect, to reflect the government enterprises and wishes and requirements, maintain the lawful rights and interests of the industry, assisting the government do a good job in industry management, in business by state ministry of industry and information related departments guidance.

Association tasks include:

Assisting the government department to make the industry technology and industry development planning;

Inside and outside the industry organization of the units concerned joint technology research and development of new products;

Suggestions for the member unit, convey to the government departments, communication circumstance;

An overview of the industry organization investigation, formulate guild regulations HangYao;

Carry out technology research, product development, investment project argumentation, evaluate consulting services;

Participate in making relevant industry standards work;

To carry out the industry management business training;

Use association website organization antistatic technology and application of the popularization and carry out market research, assist member unit to expand the market, communication production unit and the connection between the users;

Development and domestic and foreign related research institutions, enterprises and institutions, industry association, the information network and magazines, etc contact and cooperation, organization technology, product and application market exchanges, organize the domestic and international exhibitions, exhibitions and technical seminars, etc.;

Publishing industry publication national defence in electrostatic magazine, to government departments, the member unit, the related users provide free;

According to the government commission and member unit requirements, hold other relevant activities;

China's electronic instrument industry association anti-static equipment branch address:

Address: Beijing city wanda plaza CRD ginza B - 1128 room

Zip code: 100040

Telephone: (010) 68647410 51246352 fax: (010) 68647410

Web site: 66 antistatic grid

E-mail: chinaesd@chinaesd.org.cn

上海防静电工业协会

上海防静电工业协会 Shanghai Electrostatic Protective Industrial Association（缩写：SEPIA），成立于 2004 年 9 月。本协会是由从事防静电产业的企业、事业单位自愿发起组成的专业性、跨行业、跨地区的非盈利性组织，是上海市一级行业协会，社会团体法人。会员单位主要是覆盖长三角地区的生产防静电服装、地板、包装、耗材、装备设备或有关设计等领域的骨干企业，现有会员单位 105 个,理事单位 22 个。

随着我国信息化建设发展，计算机、通讯、集成电路等行业进入了快速发展期，静电危害问题突出。防静电装备、器材、工具以及防静电环境工程，生产线防静电系统等防静电产业逐步成为先进制造业配套服务的充满活力的新兴产业。由于防静电装备产品有近 100 类，2000 多种，初期生产加工相对容易，部分企业质量管理水平较低，产品生产没有标准，迫切需要加以提高。协会设：标准化委员会、专家委员会等，并投资成立具有独立法人资格的“上海工业静电技术研发服务中心”，负责技术咨询、检测、评估、组织培训、项目开发等。协会有内部季刊《上海防静电工业》。

协会成立以来，已多次牵头组织会员单位参与制定防静电方面国家、行业、地方标准；召开国际、国内有关新技术、新产品研讨会；开展相关知识、技术培训及静电专业职称申报评审等。

会长：黄建华 上海晨隆国际贸易有限公司董事长、总经理

法定代表人：黄建华

秘书长：孙君同 上海君江科技有限公司总经理、协会副会长

专职副秘书长：顾根良

协会地址：上海市虹口区车站北路 625 弄 57 号 306 室

邮编：200434

电话：021-65367650

传真：021-65369757

网址：http://www.esdchina.org.cn

电子邮箱：esd_china@esdchina.org.cn

Shanghai Electrostatic Protection Industry Association

Founded in Sep.2004, Shanghai Electrostatic Protection Industry Association (abbr. SEPIA) is a non-profit organization are voluntarily formed by electrostatic protection enterprises and institutions of professionals, cross-trades and cross-regions. SEPIA is a Class A legal body corporate of the industry associations in shanghai and social groups. Members are mainly covered the backbone enterprises of manufacturing and producing anti-static clothing, floors, packages, consumable goods, equipments, devices or related designing,etc. in the areas of the Yangtze River Delta. Currently, SEPIA holds 105 member units, among them 22 are council members.

With the development of the building- of our country's information system, the industries of computer, telecommunication, integrate circuit, etc. have been getting into a speedy developing period, but the issue of the electrostatic hazards has also become prominent to them. Thus, the industries of installation, facility, equipment, tool, environmental engineering, production line system, etc. for electrostatic protection have become vibrant new and rising ones of the Hi-Tech manufacturers with assorted supporting services. Because there were nearly 100 classifiable outfits and 2000 varieties of produts, the production and processing in part of the industries were relatively easy entry at the early stage, the standards of their products' quality control were weak in some manufactures and no criterions could be followed. So it seemed the improvement was in an urgent need.

The Association has set: the Standardization Committee and the Committee of Experts, etc. and invested in establishing a working unit of independent legal personnality " Shanghai Research and Development Service Center for Industrial Electrostatic Technology" , responsible for technical consulting, testing, evaluation, organition, training, project development. SEPIA also has its internal magazing < Shanghai Electrostati Protection Industry >published quarterly.

Since its founding, the Association has taken the leading role in repeatedly organizing its member units involved in fomulating the criterions in the fields of electrostatic protection for the country, the industry and the local; also convening domestic and international conferences and seminars for the related new technologies and new products and launching and developing trainings of technical know-how, also doing jobs on applying, assessing, evaluating and filing electrostatic professional titles, etc.

President: Huang-JianHua Chairman&General Manager of Shanghai Chen-Long International Trade Ltd.,Com.

Legal Representative: Huang-JianHua

Secretary-general: Luo-HongChang (sick leave since Feb. 2010）

Deputy secretary-general: Sun JunTong General Manager of Shanghai Jun-Jiang science and technology Ltd.,Com. Vice-President of the association

Executive Vice- secretary-general: Xiong-YanYuan

Address: R306 No.57, Lane625,Road Noth ChenZhan, Shanghai Zip:200434

Tel: 021-65367650 Fax: 021-65369757

Net: http://www.esdchina.org.cn E-mail:esd_china@esdchina.org.cn

北京电子仪器行业协会

北京电子仪器行业协会是在北京市民政局正式注册的独立法人社会团体, 成立于 1988 年 4 月，会员由电子仪器生产、销售、计量测试、高校和媒体等法人单位组成。

电子仪器行业是高技术、高效益、门类宽、应用广、发展快的基础产业也是知识密集、技术密集、资金密集的高技术投资类产业。电子仪器应用广泛，计算机、通信、航空航天、机械制造、汽车、石油、化工、冶金、医药、电力以及科研各领域均离不开电子测量仪器。

2016 年协会相应政府号召，申请并获得了团体标准制修订资格，旨在电子仪器和计量测试方面制定和发布具有创新性的团体标准。协会成立了静电防护工作组，依托有静电防护管理体系认证和产品认证能力的会员单位，开展静电防护方面的团体标准建设。为提升电子仪器行业的静电防护水平，计划开展静电防护仪器、静电防护用品、设备设施的产品质量监督，静电防护人才培训、静电防护管理体系认证等业务。协会还将积极参加静电防护产业联盟，共同建设静电防护方面的联盟标准。

协会办公地点：北京市海淀区知春路 82 号院航天恒星大厦 1116 室 邮编：100086
联系电话（传真）: 13366855901 010-68744667 010-68378158
E-mail: liumin@cast514.com

Beijing Electronic Instrument Industry Association

Beijing Electronic Instrument Industry Association is the independent legal entity social organization officially registered in Beijing Municipal Civil Affairs Bureau and was incorporated in April 1988. Its members consist of legal entity of electronic instrument production, sale, measurement test, colleges and universities as well as media, etc.

Electronic instrument industry is the basic industry with high technology, high benefit, many categories, wide application and rapid development, and the high-tech investment industry with dense knowledge, technology and capital. With the wide application of electronic instrument, the electronic measuring instrument is applied in computer, communication, aerospace, machine manufacturing, automobile, petroleum, chemical industry, metallurgy, medicine, electricity and each scientific research field.

In 2016, the association applied and gained the qualification to formulate and revise the group standard in response to the government call in order to formulate and issue the group standard with innovation in the aspects of electronic instrument and measurement test. The association established the static protection working team, and carried out the group standard establishment of static protection by relying on the member units with the static protection management system certification and product certification ability. In order to improve the static protection level in the electronic instrument industry, the association plans to carry out the product quality supervision of static protection instrument, static protection articles, equipment and facilities, static protection talent training, static protection management system certification and other businesses. The association also proactively participates in the static protection industry alliance to jointly establish the alliance standard for static protection.

Office location of association: Room 1116, Space Star Building, Yard 82, Zhichun Road, Haidian District, Beijing Postal code: 100086 Contact No. (fax): 13366855901 010-68744667 010-68378158

E-mail: liumin@cast514.com

四川航天计量测试研究所

四川航天计量测试研究所（中国航天科技集团公司七一四○计量站、国防科技工业 5111 二级计量站)隶属于中国航天科技集团公司第七研究院，位于成都国家级经济技术开发区龙泉驿区。

现建有几何量、热学、力学、电磁学、无线电电子学、时间频率、化学等七大学科的 54 项最高计量标准，具有国家和国防科技工业实验室认可的检测和校准能力 257 项。研究所拥有我国第一台 5MN 二等标准测力机、3000kg 四级高精密天平等精、大、贵、稀、关在内的测量设备 500 余台套，其计量检定与校准能力在西南地区处于领先地位。

研究所通过了国家检测和校准实验室认可、国防检测和校准实验室认可、武器装备科研生产二级保密资格认证、GJB90018-2009 质量体系认证，安全生产标准化、环境管理体系认证、职业健康安全管理体系认证等。研究所通过了国防科技工业计量技术机构设置行政许可，并被命名为“国防科技工业 5111 二级计量站”。

研究所长期履行赋予的国防系统计量检定、校准、精密参数测试、技术指导等计量保障及服务职能。目前计量服务遍及四川、重庆等省市，涵盖航天、航空、兵器、电子、核工业、部队、军工配套单位等行业。

Sichuan Aerospace Measurement and Test Research Institute

Sichuan Aerospace Measurement and Test Research Institute (7140 Metrology Station of China Aerospace Science and Technology Corporation, 5111 Level Ⅱ Metrology Station), affiliated with Sichuan Academy of Aerospace Technology , located in Longquanyi district, the national economic and technological development zone, Chengdu.

The institute has established 54 highest metrology standards related to seven main subjects involving geometrical quantity, thermology, mechanics, electromagnetism, radio electronics, and has calibration and testing capability covering 257 items accredited by China National Laboratory and Science, Technology and Industry for National Defense Laboratory. There are the first 5MN grade Ⅱ standard dynamometer, 3000kg grade Ⅳ high-precision balance in China and more than 500 sets of precise, large, valuable, unusual and crucial measuring equipment. The metrological verification and calibration capability of the institute takes the leading position in Southwest China.

The institute has passed China National Testing and Calibration Laboratory Accreditation, China National Defense Testing and Calibration Laboratory Accreditation, the Secondary Secrecy Qualification of Scientific Research and Production of Weapon and Equipment, GJB90018-2009 Quality System Certification, Work Safety Standardization Certification, Occupational Health Safety Management System Certification and so on. In addition, the institute has obtained metrology station administrative license authorized by State Administration of Science, Technology and Industry for National Defense, PRC, and is denominated 5111 Level Ⅱ Metrology Station of Technology and Industry for National Defense.

The institute performs metrological support and service functions for a long term involving national defense system metrological verification, calibration, precision parameters testing, and technical guidance and so on. So far, the metrological service has spread various provinces and cities such as Sichuan and Chongqing, which covering army, military, aerospace, aircraft, ordnance, electronic, nuclear industries and so forth.

山东电盾科技股份有限公司

山东电盾科技股份有限公司，位于山东省淄博市淄川经济开发区，是集防静电陶瓷材料研发、生产、销售、施工于一体的企业，是防静电陶瓷材料领域的领导企业。

2012 年经省科技厅批准设立 “院士工作站”、“山东省防静电工程技术中心”； 2012 年 4 月防静电陶瓷系列产品生产线建设被省政府确定为“山东省重点建设项目”；2012 年 7 月被省政府确认为“山东省战略新兴产业项目”；2012 年 10 月被省中小企业局确认为“山东省一企一技术创新企业”、并设立“山东省一企一技术研发中心”；2014 年 12 月被国家发改委认定为“新型功能陶瓷产业区域集聚发展试点项目”；2015 年 4 月获“设计师信赖的建筑材料奖”。 2015 年 5 月 5 日经山东省发展和改革委员会认定：山东省防静电功能陶瓷工程研究中心。2015 年 11 月公司的防静电瓷砖发明专利荣获第十七届中国专利优秀奖。

公司拥有 19 项国家专利，是国家强制性标准 GB26539-2011《防静电陶瓷砖》主要起草单位，参与起草国家标准 GB50944-2013《防静电工程施工与质量验收规范》、GB50462-2015《数据中心基础设施施工与质量验收规范》、《防静电活动地板通用规范》(起草中)。

防静电陶瓷砖产品经山东省科技厅科技成果鉴定为“填补国内空白，技术性能处于国际领先水平”。

公司的产品已广泛应用于国防、航天、航空、通讯、化工制药、石化、微电子、电力、教育、矿业、金融等领域。

电盾科技将秉承“专业、责任、稳健、诚信”的经营理念，为广大客户提供优质的产品和专业的服务。

Shandong Diandun Science and Technology Holdings Co., Ltd

Shandong Diandun Science and Technology Holdings Co., Ltd, located at Zichuan Economic Development Zone of Zibo in Shandong Province, China, is a leading hi-tech company among the anti-static ceramics material industry, and focuses on the R&D, production, sales and construction of anti-static ceramics material.

In March of 2012 “Academician Workstation ” and “Shandong Anti-static Engineering Technology Center” was set up with the approval of Science and Technology Department of Shandong Province. In April of 2012 manufacturing of anti-static products was awarded as “Shandong Major Construction Project”. In July of 2014 the company was praised as “Shandong Strategic Emerging Industry Project” by Shandong Provincial Government. In October of 2012 the company got the honor of “Innovative Company with One Technology Invented by the Company” and established Shandong Small and Medium Company Management Bureau, and meanwhile the company was approved to establish “Shandong Research and Development Center of One Enterprise with One Focus Technology” by Shandong Bureau of SME. In December of 2014 was approved as “New Functional Ceramic Tile Industry Regional Central Development Pilot Project”. In April of 2015 the products of the company were awarded “National Architect Trustworthy Building Material”. On May 5th 2015 the company was verified as “Shandong Anti-static Functional Ceramics Engineer Research Center” by Shandong Development and Reform Commission. In November of 2015, the company’s anti-static ceramic tiles was honored to win “the 17th Chinese Patent Excellent Award”.

The company owns 19 items of national patents, the main initial unit who drafts the national compulsory standard GB26539-201 *“Anti-static Ceramic Tiles”,* the national standard GB50944-2013 *“Specifications for the Anti-static Program Construction and Quality Acceptance”,* GB50462-2015 *“Database Center Infrastructure Construction and Quality Acceptance”, “Anti-static Raised Floor General Specifications ”*(Drafting).

Products of anti-static ceramic tiles have been identified by Shandong Science and Technology Department “to fill up the technology blank in China and take up at the international peak level”.

The company’s products have been widely applied into industries and fields such as National Defense, Aviation, Communications, Chemical and Pharmaceutical, Petro-chemical, Micro-electrics, Grid, Education, Mining Industry, and Financing etc.

Shandong Diandun Science and Technology Holdings Co., Ltd adheres to the business operation concept of “Professional, Responsible, Stable and Honest” to serve the customers with superior products and service.

上海佰斯特电子工程有限公司

上海佰斯特电子工程有限公司作为国内唯一一家具有生产资质专业防静电产品的生产厂家，在经过近 20 年不断发展，目前在国内航天航空、电力、电子、通信、半导体、汽车、船舶、自动化系统、光电、机械制造、机器人、仪器仪表、医疗及各大院校等领域完成了一系列一条龙服务工程，且得到了客户的一致认可及高度好评。 佰斯特一直致力于为客户提供人性化、模块化、高品质和极致设计的工业品整体解决方案，旗下产品涵盖：防静电产品系列、实验室家具系列、工业品正品大全系列三大类别，上万种产品种类。佰斯特在中国市场至今已经服务了上万个客户，特别是在军工企业和光电通信行业知名度非常高，同时在全国主要城市进驻了现场销售以及技术服务人员，并在 2013 年与德国历史悠久的工业品供应领域专业公司 FPS GMBH 合作，成立 FPS-POUSTO GMBH，新公司在欧洲和中国市场专业提供您车间及物料储存等领域一站式的采购服务，未来我们将在工业品领域继续为您提供优质的服务。

Shanghai Pousto Electronic Engineering Co., Ltd.

Pousto, the only qualified professional anti-static manufacturer domestically, has the ability to offer a series of one-stop service project, including domestic aviation, electric power, electronics, communication, semiconductor, automotive, Marine, automation systems, photoelectric, machinery manufacturing, robotics, instruments and meters, medical and universities' projects as well after nearly 20 years development, and has got the customers' consistent approval. Pousto has been committed to providing customers with humanity, modular, high quality and best design of industrial products with an integrated solution. Its business ranges from Anti-static products series, Laboratory furniture series to Industrial quality goods series, thousands of kinds of products included. Pousto has offered services for about ten thousands of customers, especially well-known in military enterprise and photoelectric communication industry, meanwhile our sales and technical service center are stationed in major cities in China. In 2013, Pousto cooperated with the German FPS GMBH which has a long history of professional industrial supplies company, and jointly established FPS - POUSTO GMBH. Our new company will provide workshops and material storage areas with professional one-stop procurement services in Europe and China; also we will continue to provide you with quality services in the field of industrial products in the future.

一远静电科技有限公司

一远静电科技有限公司是一家集电子材料研发设计、制造加工服务的高新技术企业。属下有防静电及净化(ESD&CLEANROOM)系列产品、无铅焊料(LEAD—FREE SOLDERS)，各种芯片程序(ICPROGRAMMNG)烧录加工三个事业群。

公司自 1995 年创办以来，以科技为依托，市场为导向，与国内外多家大专院校及知名企业合作，共建科技创新载体，多次承担完成国家重大科研攻关项目，获得多项发明成果，是国家高新技术成果产业化及“863”成果产业化企业基地。

一远静电科技有限公司专业从事研发、生产、销售防静电橡胶板(台垫、地垫)、防静电服装、防静电鞋、无尘抹布、防静电椅等防静电及净化系列产品。公司目前拥有 7 套国内最先进的防静电橡胶板(台垫、地垫)生产流水线，年产防静电橡胶板(台垫、地垫)90 万平方米、拥有年产防静电服、净化服和防静电鞋 70 万套、无尘抹布 300 万包、防静电椅 16 万把的高标准洁净车间。产品已遍及全国，大量出口新加坡、美国、英国、德国、日本等国。下属防静电技术研究所专业从事防静电产品的研究开发及产品质量的跟踪、检测。在国内最早实现了产业化、为航天、国防、石油、医药、食品、电子、化工、煤矿等行业提供技术和产品，大量代替了国外进口，成为了伟创力、捷普、华为、夏普、中兴等全球领先电子制造的指定使用品牌，在业内具有良好的信誉，被国家科学技术委员会专家鉴定为“技术处于国内领先，质量达到国外同类产品先进水平”。

YIYUAN Electronic Technology Co, Ltd

YIYUAN Electronic Technology Co, Ltd is a high-tech company specialized in electronic material products research and development, products designing and manufacturing. The company has three main business parts including ESD & CLEANROOM products ,LEAD-FREE SOLDERS and IC-PROGRAMING.

Established in 1995, the company follows the principle of Technology-based and Market-oriented, and has cooperated with a number of domestic and international universities and well-known companies to develop new techniques and products. YIYUAN completed many national science and technology research projects, including 'National 863 Project'; moreover, the company owns a number of patent products.

YIYUAN specialized in ESD & CLEANROOM products' research and development, manufacturing, and selling; products include anti-electrostatic rubber mat, conductive mat, anti-electrostatic clothes and shoes. YIYUAN is one of the earliest companies to achieve the industrialization of anti-electrostatic technology in China. Company has 7 sets of the most advanced anti-static rubber sheets convey belt production line. Company's annual production has 900.000 square meters anti-static rubber mat, 700,000 sets of anti-static cloth, cleaning cloth and anti-static shoes, 3,000,000 bags of cleaning cloth and 160,000 anti-static seats. The products have been sold all over the world. The company provides products to aerospace industry, national defense, oil, medicine, food, electronics and chemical industry. The products provided by YIYUAN have been widely imported from abroad. Moreover, YIYUAN has a good reputation in the ESD industry, and the company has built long business relationship with the world's leading electronic manufacturers, such as Flextronics, Jabil, Sony and Huawei. In addition, YIYUAN is honored "Advanced technology in domestic and the same level product quality in abroad" by National Science and Technology Institute.

"Customer first and striving for excellence". YIYUAN will provide more and more outstanding ESD & CLEAROOM series products to our clients. Customers' needs help YIYUAN make progress and improvement. Sincerely hope YIYUAN's service can offer assurance quality for you.

北京谱脉技术有限责任公司

北京谱脉技术有限责任公司是从事静电防护产品销售、静电防护技术服务的专业公司，为客户提供防静电系统技术咨询、防静电产品配套、防静电地面工程施工等服务，在防静电工程的设计、施工等方面具有丰富的经验和良好的业绩，承接实施了国内许多著名企业、中外合资企业以及外资企业以及航空航天科研单位、企业的防静电配套工程。

我公司同时也是国外著名专业厂家——美国 ACL 公司在中国国内的总经销商。为客户提供优质、环保产品——STATICIDE 系列防静电地板涂料、除静电剂、防静电清洗剂等，销售美国 ACL 公司生产的系列静电测试仪表。

我公司还为用户提供防静电手腕带、防静电脚跟带、接地组件、防静电台垫、防静电工作服、防静电鞋、防静电包装材料、防静电周转箱/车、防静电工作台/架、防静电椅等其他配套产品，代理销售韩国、马来西亚、新加坡、台湾等厂家的产品。

Beijing ProMax Technologies, Inc

Beijing ProMax Technologies, Inc is the professional company engaging the sale of static protection product and the static protection technology service. It provides the customers with the anti-static system technology consultation, anti-static product supporting, anti-static ground engineering construction and other services, and has rich experiences and good performance in the design, construction and other aspects of anti-static engineering. The company undertakes implementing the anti-static supporting engineering of many domestic famous enterprises, Sino-foreign joint ventures, foreign capital enterprises, aerospace R&D institution and enterprises.

Our company is also the foreign famous professional manufacturer -- the domestic sole distributor of America ACL company in China. It provides customers with high-quality and environment-friendly products--STATICIDE series anti-static floor coating, destaticizer, anti-static detergent, etc., and sell the series static test instrument produced by America ACL company.

Our company also provides the customers with anti-static wrist strap, anti-static heel strap, grounding component, anti-static table pad, anti-static uniform, anti-static shoes, anti-static packing materials, anti-static turnover box /vehicle, anti-static workbench /work frame, anti-static chair and other supporting products, and sells the products from manufacturers in Korea, Malaysia, Singapore, Taiwan, etc. as an agent.

山东中电陶瓷有限公司

山东中电陶瓷有限公司是以陶瓷生产、设计、销售为一体的现代化大型陶瓷企业，注册资金 500 万元，是中国防静电协会会员，公司位于山东省淄博市淄川建材城工业园区，占地面积 300 亩，现有多条生产流水线，目前现有员工 1200 人，其中工程技术人员 120 人，主要生产高档全瓷釉下彩喷墨仿古艺术砖、喷墨微晶石砖、防静电瓷砖、架空陶瓷地板等系列，各项指标均达航天标准及静电体系认证要求，产品销往全国各地及海外，在北京、上海、深圳、苏州等城市设立了销售中心。

公司秉承“诚信天下”，保证一流质量，坚持“客户第一”的原则创新谋发展的经营理念，加大建设科研队伍，全力打造企业品牌，不断提高产品技术含量。先后通过 3C 强制认证、ISO9001 质量体系认证。公司的产品已广泛应用于航天、国防、电子、通讯、化工、光学仪器等高科技尖端领域，在业内有良好的品牌和信誉。产品质量得到国家信息产业部防静电产品质量监督检验中心认可。

“客户至上、追求卓越”。山东中电将不断为客户提供更多、更出色的防静电系列产品。有您的需求才有我们的发展，有您的要求才有我们的提高，让我们的产品给您带来品质的保障。

Shandong Zhongdian Ceramics Co., Ltd.

Shandong Zhongdian Ceramics Co., Ltd., one of the modern large-scale ceramic enterprises, mainly focuses on ceramic production, design, and marketing. With a registered capital of 5 million yuan and a member of China's anti-static Association, the company is located in Zibo City, Shandong Province Building Materials City Industrial Park, covering an area of 300 acres. With the existing production lines and the current 1,200 employees, including engineering and technical personnel of 120 people, the company mainly covers the production of high-end full-color ink-jet under enamel antique art tiles, inkjet microcrystalline stone tile, anti-static tiles, overhead ceramic floors and other series. All index reach the aerospace standard and static system certification requirements, and products are sold throughout the country and overseas, with sales centers in Beijing, Shanghai, Shenzhen, Suzhou and other cities.

Besides following the belief of "integrity of the world" to ensure the best quality, the company also sticks to the business philosophy of "customer first" to develop by way of innovation. With a big endeavor on the construction of the research team, the company intends to build a corporate brand, and constantly improves the technological standard. It has passed 3C compulsory certification, ISO9001 quality system certification. The company's products have been widely used in the aerospace, defense, electronics, telecommunications, chemicals, optical instruments and other high-tech cutting-edge areas, and have earned good reputation. They have been recognized by the State Ministry of Information Industry Static Control Products Quality Supervision and Inspection Center .

With the belief of "Customer First, the pursuit of excellence", Shandong Zhongdian Ceramics Co., Ltd. will continue to provide more better anti-static products. It's your needs and request that drive us to make progress. Shandong Zhongdian will continue to offer products with high quality to lay foundation for your development.

北京东方计量测试研究所

北京东方计量测试研究所成立于 1985 年，又称为中国航天科技集团公司第五研究院第五一四研究所，是中国空间技术研究院所属的专业计量测试研究所。

北京东方计量测试研究所是国防科技工业电学一级计量站，是集电磁学、无线电电子学、时间频率、几何量、热学、力学、真空、卫星应用、静电防护和电磁干扰等专业为一体的综合性计量测试研究所，承担着我国国防科技工业、军队系统特别是航天和空间技术领域量值传递和计量校准测试任务，开展计量标准装置和测试设备研制、测量技术和测试方法研究、能力验证和比对、计量人员培训和计量标准考核等工作，同时面向社会提供公正的校准、检测和检验服务。

北京东方计量测试研究所是博士、硕士研究生培养单位，是国家批准的“仪器科学与技术”硕士学位一级学科点。现有博士生导师、硕士生导师、学科带头人后备人员 10 多名，与国内外技术、学术团体有着广泛的接触与联系。

近年来，北京东方计量测试研究所积极开展了航天型号产品相关的静电防护技术研究，承接了多项静电相关的星船地面试验任务，负责起草了中国空间技术研究院的静电防护管理体系院标 Q/W 1300~1303、中国航天科技集团公司静电体系标准 Q/QJA 118~123、国军标 GJB/J 5972-2007《非接触静电电压表校准规范》以及国家标准 GB/T 32304-2015《航天电子产品静电防护要求》等，是航天科技和五院静电防护管理体系的技术支撑单位，已经组织开展了航天科技、航天科工、中电集团、中科院、战略支援部队等多家单位的航天电子产品静电防护管理体系建设和认证工作并收到良好效果。

同时，北京东方计量测试研究所主动搭建静电防护产业化发展生态，具备技术研究、产品检测、物资配货、工程施工、培训咨询、体系认证、产品认证等基础业务服务以及静电防护系统解决方案提供能力，具有国家认监委批复筹建的国家静电防护产品质量监督检验中心、工信部授权的工业（静电防护）产品质量控制和技术评价实验室，是国家认监委授权的国家静电防护产品认证机构，建设了院士专家工作站，通过设立院士工作站静电研究基金等方式，逐步搭建全国性静电专家研究平台，推动我国静电防护技术研究和标准化发展。诚邀各领域专家加入平台，共谋发展！

Beijing Orient Institute of Measurement & Test (BOIMT)

Founded in 1985, Beijing Orient Institute of Measurement & Test (BOIMT) is a metrological institute, subordinated to China Academy of Space Technology (CAST).

BOIMT is tasked with establishing, maintaining and improving measurement standards and conducting research on relevant technologies to achieve more precise measurement. BOIMT plays an important role in every development process of the spacecraft. Each year, BOIMT calibrates approximately 90 thousands set of equipments for CAST.

The calibration services of the institute mainly relate to electromagnetic calibration, radio calibration, time and frequency calibration, geometrical calibration, mechanics calibration (including vacuum calibration), etc. Up until now, BOIMT has established 43 measurement standards, including 14 national-defense primary electrical standards. BOIMT provides essential guard for the accuracy and reliability of quantity values within national-defense system. Especially, it has advanced electrical calibration standards, such as Quantum Hall resistor primary standard and Josephson Voltage primary standard, which have reached the international advanced level.

BOIMT has engaged in electrostatic field for years, and drafted series of standards, for instance, the electrostatic discharge protection management system (Q/W1300-1303), including electrostatic discharge protection management system requirements, technical requirements for electrostatic discharge protection, test requirements for electrostatic discharge protection system and configuration requirements for electrostatic discharge protected area, and the national standard as well, which is Electrostatic discharge protection requirements for aerospace electronic products（GB/T 32304-2015）.What's more, BOIMT is the technical unit of electrostatic discharge protection, and Electrostatic Discharge Certification of CAST, and initiated the establishment of electrostatic discharge protection management system for such enterprises as China Aerospace Science and Technology Corporation (CASC), China Aerospace Science & Industry Corporation (CASIC), China Electronics Technology Group Corporation (CETGC), Chinese Academy of Science (CAS) and the PLA Strategic Force, which have achieved good results.

At the same time, BOIMT takes the initiative in pursuing the ecological development of electrostatic protection industry, with the systematic solution for electrostatic protection and the ability of technical research, product testing, material distribution, engineering construction, training, consulting, system certification and product certification and other basic services.

BOIMT has been authorized as the unit for anti-static products certification and the quality supervision and inspection center for anti-static products (under-construction) by Certification and Accreditation Administration of the People's Republic of China (CNCA). Ministry of Industry and Information Technology (MIIT) has also granted BOIMT to the quality control and technical evaluation laboratory for ESD products. Furthermore, by establishing academician workstation and the anti-static research fund along with it, BOIMT has gradually set up a national research platform to promote the development of electrostatic protection technology and standardization in china. Warm welcome experts in all fields to join in this workstation and progress together!

中国标准化杂志社

中国标准化杂志社是由中国标准化协会和中国标准化研究院的全资公司——中国标准科技集团有限公司共同出资的股份制企业。由国家质检总局主管，中国标准化研究院和中国标准化协会共同主办。本着顺应国家新闻出版总署关于中央新闻出版业文化体制改革精神的要求，依据国家新闻出版总署及有关部门规定，经国家质检总局同意，2010 年 9 月，由中国标准化研究院主办的标准科学杂志社(出版刊物为：《标准科学》、《标准生活》、《术语标准化与信息技术》)与中国标准化协会主办的中国标准化杂志社（出版刊物为：《中国标准化》、《China Standardization》）正式合并，2011 年 12 月《术语标准化与信息技术》更名为《产品安全与召回》。现五本杂志涵盖了中国标准化领用领域的政策形势时事政策、发展动态、研究成果、国行标权威发布、标准科技前沿和热点探讨、标准化理论与实践、中国标准化文化历史，以及与百姓生活息息相关的标准知识普及等内容，是目前中国标准化领域最全面、最权威和最具实力的传媒机构。

China Standardization Press

China Standardization Press is a professional media institution in the field of standardization jointly established by China National Institute of Standardization (CNIS) and China Standardization Association (CAS). It is dedicated to be an authoritative media group in China standardization and make great contributions to its development.

China Standardization Press has five journals:

China Standardization (Chinese)

Started in 1958, it is the most influential professional media in China's standardization field.

China Standardization (Overseas)

Started in 2004, it reports the China standardization development in an all-round to the international community, expressing the viewpoints of experts from home and abroad and displaying the standardization culture with Chinese characteristics. It is the only English journal for exchange with overseas standardization organizations.

Standard Science

Started in 1964, it is a core journal in science and technology in China focusing on probing and research of theories of standardization science. It is also a platform for communication of standardization theory and academic exchanges.

Standard Living

Started in 1964, it is a fashionable magazine for science popularization, using popular and easy ways to explain standards, plain and simple language to report news of standardization, and adopting shocking cases to strengthen standards, so as to serve as a standardization guide for common people.

Product Safety and Recall

Started in 1996, it was originally named as Terminology of Standardization and Information Technology. It is professional periodical for introduction of policies, laws, regulations and standards of product safety, analysis of current status and development trend of product safety management at home and abroad, summing up and exchange of experiences in enterprises' product safety management, promotion of product safety technologies, and popularization of product safety knowledge.

西安空间无线电技术研究所

西安空间无线电技术研究所（中国空间技术研究院西安分院）隶属于中国空间技术研究院，中国空间技术研究院隶属于中国航天科技集团公司，西安分院是中国最大的宇航分系统及单机供应商，经营的范围包含：飞行器有效载荷、数据传输分系统相关的单机产品的设计、研发、制造、集成及测试，西安分院成立于 1965 年 6 月 29 日，在过去的 50 年中西安分院为超过 140 多颗星船提供了分系统和单机及产品。140 多颗星船包括了通信、导航、对地观测、探月工程、神舟载人飞船等任务，西安分院主要技术领域包括：

- 通信和导航

西安分院是中国通信卫星的主要供应商，也是北斗一号、北斗二号卫星载荷的供应商，同时还是中国地面及星载遥控、遥测的系统供应商，还是中国第一颗中继卫星的有效载荷供应商。

- 数据传输

西安分院是中国高速数据传输分系统和单机的关键供应商。

- 星载天线

西安分院是中国星载天线最主要的供应商。

- 微波

西安分院是中国微波单机产品最有竞争力的供应商。

西安分院现有员工 2700 多人，通过一系列卫星项目，其中 2014 年实现收入 40.9 亿元。

Academy of Space Electronic Information Technology

Academy of Space Electronic Information Technology (CAST Xi'an) is a subsidiary of China Academy of Space Technology (CAST) within China Aerospace Science and Technology Corporation (CASC). It is the Chinese largest supplier of subsystem and equipment for spacecraft. Its activities cover development, design, manufacturing, integration and test of spacecraft payloads, TT&C sub-system, as well as related electronic equipment.

CAST Xi'an was initially founded on June 29, 1965. Over the five decades, CAST Xi'an has supplied products at both system level and equipment level for more than 140 spacecrafts for communication, navigation, Earth observation, Moon exploration and Chinese Shenzhou Spaceflight mission, with its superior technology in the following four fields:

Communication and Navigation

CAST Xi'an is a major supplier for Chinese communication satellite payloads; is the supplier for all Beidou-1 and Beidou-2 navigation satellite payloads; is the pioneer in Chinese ground and space based TT&C system; is the supplier of the payload for the first Chines Data Relay satellite.

Data Transmission

CAST Xi'an is a key Chinese supplier of high speed data transmission subsystem and equipment for satellites.

Space-born Antenna

CAST Xi'an is a top leader of space-born antenna in China.

Microwave

CAST Xi'an is the most competitive supplier of microwave equipment for spacecraft in China.

CAST Xi'an employs around 2700 people. With space projects and institutional programs, it has achieved revenue of 4.09 billion RMB in 2014.

演讲文稿

Presentations

刘尚合

刘尚合，中国工程院院士。现任军械工程学院静电与电磁防护研究所所长、教授、博导；电磁环境效应国家级重点实验室学术委员会主任；中国兵工学会常务理事；国家自然科学基金委员会学科评审专家；中国信息与电子工程科技“电磁场与电磁环境效应”学科领域专家组组长；国防预研专业组组长；国家重点学科学术带头人。

刘院士主要从事电磁兼容与电磁防护方向的研究生培养和科研工作。先后获国家科技进步一等奖 1 项、二等奖 1 项；全国科学大会奖 1 项；省部级科技进步一、二等奖 9 项；获国家发明专利 12 项，出版专著 3 部，发表学术论文 200 余篇，指导的博士研究生论文获全国百篇优秀博士学位论文。被评为全国优秀教师，获中国静电研究与应用重大贡献奖和中国人民解放军专业技术重大贡献奖。

Liu Shanghe

Liu Shanghe, academician of Chinese Academy of Engineering, director of the Institute of Electrostatic and Electromagnetic Protection of Ordnance Engineering College, professor, doctoral supervisor; director of the academic committee of National Key Laboratory for Electromagnetic Environmental Effects, executive director of China Ordnance Society, disciplinary evaluation expert of National Natural Science Foundation Committee; leader of "electromagnetic field and electromagnetic environment effect" expert group of Information Technology & Electronic Engineering; leader of national pre-research professional team; academic leader of national key disciplines.

Liu mainly engages in the graduate teaching and research work on electromagnetic compatibility and protection. He has won national scientific and technological progress prizes class one once, class two once, National Science Conference Award once, and the provincial and ministerial level scientific and technological progress prize class one or two nine times. He also has twelve national invention patents, 3 monographs, over 200 papers, with his guidance of PhD thesis retrieved by the National excellent Doctoral Dissertation. Liu has been named the national outstanding teacher, excellent teacher of the whole army, the army heroes on behalf of the General Armament Department, outstanding communist. He has two significant contribution awards, one by electrostatic research and application, and the other by the PLA professional technology.

静电危害及防护

刘尚合

电磁环境效应国家级重点实验室
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本讲主要内容

一、静电放电特点及静电危害
二、静电危害防护
三、静电测试与评价中应注意的几个问题
四、结束语

一、静电放电的特点及静电危害

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1、静电放电特点

静电放电有时会形成：

- 高电位、强电场
- 瞬态大电流
- 宽带电磁干扰

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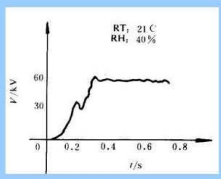

人体在着尼龙绸褂衣、晴纶内毛短大衣，穿红塑料底布鞋在干燥地面上，脱短大衣时，人体的起电波形。

一、静电放电的特点及静电危害

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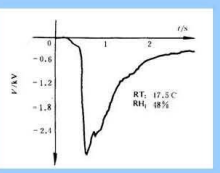

人坐绒面电镀椅，穿防静电鞋，在木地面上突然站起时，人体起电、放电的波形

一、静电放电的特点及静电危害

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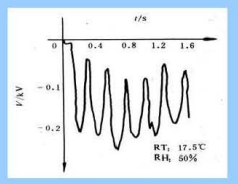

人穿红塑料拖鞋，在水泥刷漆地面上行走时，人体的瞬态电位波形

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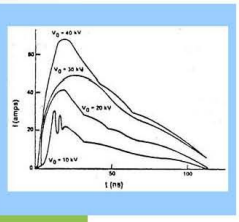

一、静电放电的特点及静电危害

静电放电瞬态大电流导致国外卫星典型故障事例

- 法国通信卫星姿控计算机故障

法国通信卫星Telecom-1B由于静电放电（瞬时值达几十安培）产生的电磁脉冲耦合到卫星内部，导致卫星主备份姿控计算机均发生故障，卫星失效。

Telecom-1B卫星姿控计算机均发生故障

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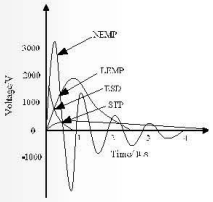
静电放电过程产生的电磁辐射场覆盖很宽的频谱范围，有的报道达到0～3GHz。

一、静电放电的特点及静电危害

1、静电放电特点

静电放电作为近场危害源，产生的电磁脉冲可与LEMP、HEMP、STP的作用相提并论。



一、静电放电的特点及静电危害

2、形成危害的几种效应

- 力学效应
- 热效应
- 电磁辐射效应
- 强电场效应
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静电场使物质微粒极化，从而产生静电引力，使悬浮在空气中的尘埃容易被吸附在物体上造成污染。如果半导体芯片带上静电，尘埃会吸附在芯片上，使得集成电路的成品率大大降低。

静电场的库仑力作用使纺织、印刷、塑料包装等自动化生产线受阻。

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静电放电产生的热效应是在ns或μs量级完成的，是一种绝热过程，作为点火源、引爆源，瞬时可引起易燃易爆气体或电火工品等燃烧爆炸；可以使微电子器件、电磁敏感电路过热，造成局部热损伤，电路性能变坏或失效。

绝热效应

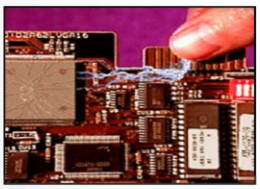
序号	型号名称	电阻/Ω	发火条件	安全条件		50%发火能量/mJ
				I/mA	t/s	
1	JD-11 电点火具	1.25~2.25	700mA	180	5~10	1.73
2	JD-1 电点火具	0.15~0.80	6V	150	300	12.0
3	DD-4.5 电点火管	2.5~4.5	400mA	50	300	1.00
4	DD-17 电点火管	12~17	500mA	25	30	0.225
5	105电火帽	15~60	24V串4Ω	0.1μF, 45V		0.270

以JD-11电点火具为例：计算其安全能量为729mJ，而在脉冲作用下，其50%发火能量仅为1.73mJ。

JD-1电点火具安全能量为5.4J，而在脉冲作用下，其50%发火能量仅为12mJ。

绝热效应对电路造成的危害

随机EMP一般是在微秒或纳秒量级完成的，因此,是一种绝热过程。对微电子器件而言，其放电能量是在0.1μs时间内通过器件电阻释放的，其平均功率可达几千瓦，在器件内形成大的温度梯度、造成局部热损伤。



ESD热效应造成微电子电路损伤的模式

ESD热效应

- 金属布线与扩散区（或多晶）接触孔产生火花，使金属和硅的欧姆接触被破坏。
- 使局部的硅熔解，产生再结晶，造成器件短路。
- 金属化电极和布线熔解、“球化”，造成电路开路。
- 大电流流过PN结产生焦耳热，使结温升高，形成“热斑”或“热奔”，导致器件损坏。

静电放电热效应导致国外卫星典型故障事例

- 日本地球观测卫星电源线烧毁

日本地球观测卫星（ADEOS-II）通过极区时，高能电子引起的内带电效应烧毁了太阳电池阵和卫星主体间的部分供电电缆，导致卫星功率从6KW下降到1KW，卫星大部分功能丧失。

ADEOS-II卫星发生电源线烧毁

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- 强电场效应
- 磁效应

静电放电引起的射频干扰，对信息化设备造成电噪声、电磁干扰，使其产生误动作或功能失效。强电磁脉冲可以形成累积效应，造成器件或电路的性能参数劣化或完全失效，使电路或设备的可靠性降低。

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- 磁效应

静电危害源形成的强电场不仅可以使MOS场效应器件的栅氧化层击穿或金属化线间介质击穿，造成电路失效，对电绝缘提出了更高的要求。强电场还可引起潜在性失效。

ESD强电场效应造成微电子电路损伤的模式

ESD 强电场效应

强电场导致MOS场效应器件的栅氧化层被击穿，使器件失效。

强电场导致微电子电路绝缘介质击穿，或使器件性能下降。

强电场使集成电路和精密的电子组件老化，降低设备寿命。

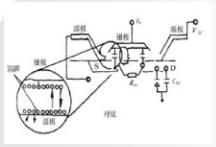
静电放电强电场效应导致国外卫星典型故障事例

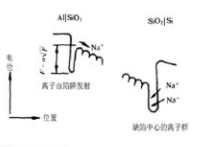
- 美国国防通信卫星电缆击穿

美国国防通信卫星DSCS-II (9431)由于电缆表面静电电压超出电缆击穿阈值的130%，通讯系统供电电缆击穿，导致卫星失效。

DSCS-II卫星发生电缆击穿

潜在性危害

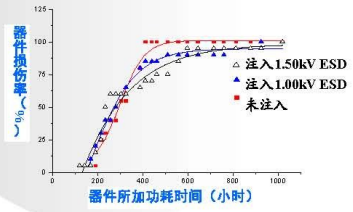




当MOS器件栅极上外加电场时，在该电场作用下，如果栅极没有被击穿，则也可以使SiO_2膜中Al / SiO_2 界面处所俘获的Na+离子漂移而群集在SiO_2 / Si界面的缺陷中心处，为器件使用中局部击穿埋下隐患，造成潜在性危害。

潜在性危害

◆EMP会造成部分器件出现时间相关的潜在性失效，但也使另一部分器件的使用寿命有所提高。



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静电放电引起的强电流可产生强磁场，干扰电子设备的正常工作。因此对信息化设备的设计和磁屏蔽材料的选择都提出了苛刻的要求。

一、静电放电的特点及静电危害

3、危害举例 （1）静电放电导致国外部分卫星故障

序号	卫星	故障	损伤部位
1	美国DSCS-II (9431)卫星	通信系统断断续续中断，卫星失效	姿态系统
2	日本ADEOS-II卫星	太阳阵率卫星主体间的电缆损坏，功率下降，功能丧失	
3	阿拉伯卫星通讯组织Arabsat 1-A卫星	姿控系统发生故障，转为备份星	
4	欧空局MARECS-A卫星	太阳阵损坏、功率下降，卫星服务中止	
5	欧空局Meteosat-F1卫星	姿控系统发生故障	
6	日本ETS-6卫星	太阳电池基板击穿，功率下降	
7	加拿大—美国CTS卫星	电源二极管失效，导致一根电源母线烧毁	
8	美国DSCS-II (9432)卫星	姿控系统连续异常，卫星失效	
9	欧空局Meteosat-F2卫星	姿控系统发生故障	
10	法国Telecom 1B卫星	主备份姿控系统故障，卫星失效	电子系统
11	美国Intelsat K卫星	动量轮控制电路故障	
12	加拿大Anik E-1卫星	陀螺仪故障	
13	加拿大Anik E-2卫星	主备份姿控系统均发生故障，卫星失效	
14	美国Telstar 401卫星	姿控系统故障	
15	美国Intelsat K卫星	动量轮控制电路故障	
16	美国NATO-3A卫星	姿控系统故障	

3. 危害举例

静电放电导致国外部分卫星故障（续表）

序号	卫星	故障	损伤部位
17	日本BS-3A卫星	60分钟遥测记录丢失	电子系统
18	澳大利亚AUSSAT-A3卫星	姿控系统遥测开关故障	
19	美国FLTSATCOM 6071卫星	发生5次逻辑错误	
20	澳大利亚AUSSAT-A2卫星	姿控系统故障	
21	澳大利亚AUSSAT-A1卫星	姿控系统故障	
22	美国Intelsat 511卫星	姿控系统故障	
23	美国Telstar 401卫星	姿控系统故障	
24	美国Intelsat 510卫星	姿控系统故障	
25	加拿大Anik D-2卫星	消旋控制系统故障，通讯中断	
26	法国Telecom 1A卫星	通讯故障，转为备份星	
27	美国TDRS-1卫星	控制系统故障	
28	美国TDRS-3卫星	姿控系统处理器电路故障	
29	美国TDRS-4卫星	姿控系统故障	
30	美国TDRS-5卫星	姿控系统故障	
31	美国SBS 1卫星	姿控系统电路故障	
32	美国DSCS-II (9443)卫星	逻辑错误	

3. 危害举例

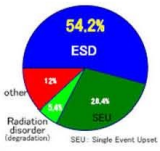
静电放电导致国外部分卫星故障（续表）

序号	卫星	故障	损伤部位
33	美国NATO-3C卫星	姿控系统故障	电子系统
34	美国NATO-3B卫星	姿控系统故障、指令异常	
35	美国DSCS-II (9438)卫星	逻辑错误	
36	美国DSCS-II (9442)卫星	逻辑错误	
37	法国—德国Symphonie A/B卫星	逻辑翻转	
38	美国Skynet 2B卫星	遥测和控制系统电路故障	
39	美国ERBS卫星	指令单元工作异常	
40	美国DSCS-III (4524)卫星	转速测试系统故障	
41	日本GMS-4卫星	红外可见扫描辐射计故障	敏感部件
42	日本GMS-3卫星	加速计异常、红外可见扫描辐射计故障	
43	美国GOES-6卫星	X射线扫描仪故障	
44	美国GOES-4卫星	辐射计和大气探测器失效，卫星服务中止	
45	美国SCATHA卫星	数据丢失、磁场探测器和等离子体分析仪均发生故障	
46	美国Viking Lander 1卫星	质谱仪工作异常	
47	加拿大Anik B-1卫星	热控涂层性能下降	功能材料
48	美国Landsat-3卫星	传感器污染加重	

3. 危害举例

国外统计表明：静电放电是导致卫星产生故障的主要原因

2007年NASA统计了4家权威机构数据库，表明国外发生的326起空间环境引发的卫星故障中，静电放电效应占54.2%。



国外空间环境故障的比例图

Sources of Data

(1) Spacecraft Anomaly Manager (SAM). This database is maintained by NOAA/NGDC in Boulder, Colorado. This database primarily contains anomalies that are believed to have been caused by the space environment.

(2) NASA Anomaly Reports [*Bedingfield et al.*, 1996; *Leach and Alexander*, 1997].

(3) The anomaly database maintained by the US Air Force 55th Space Weather Squadron.

(4) Individual Program Offices databases.

引用文献

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（2）火箭飞行失败统计表

序号	火箭名称	飞行试验代号	发射时间	高度/km	真空度/mmHg	故障简况及原因
1	民兵I	FTM-502	1962	7.6	316	静电放电造成制导计算机故障，I级发动机关闭前自毁，发射失败
2	民兵I	FTM-503	1962	21.8	39.6	静电放电造成制导计算机故障，I级发动机关闭前自毁，发射失败
3	欧罗尼II	F-11	1971	27	7.94	静电放电使制导计算机阻塞，姿态失控，约1分钟后，火箭I、II级过载自毁，发射失败
4	侦察兵	S-112	1964	38-42	3.09-1.86	电爆管桥丝和壳体之间因电弧击穿，II级发动机自毁系统爆炸，发射失败
5	侦察兵	S128	1964	38-42	3.09-1.86	电爆管桥丝和壳体之间因电弧击穿，II级发动机自毁系统爆炸，发射失败
6	大力神IIIC	C-10	1967	26	8.94	静电放电使制导计算机故障后自动转移到应急后备状态
7	大力神IIIC	C-14	1967	17	52	静电放电使制导计算机故障后，经地面发射指令，修正到预定轨道
8	德尔安	2313	1974			制导系统控制器件故障，火箭程序发射失败

3. 危害举例

（3）静电对飞机燃油系统的危害

F-15战斗机在维修时，由于燃油系统接地不正确，人体未采取防静电措施，静电放电造成飞机彻底毁坏。

3. 危害举例

（4）静电对电子系统的危害

单片机系统ESD电磁脉冲效应实验结果

- ESD EMP能对工作于各种程序模块下的单片机系统产生干扰，在所有故障现象中，控制状态改变最易出现. 人体金属模型垂直耦合板放电的干扰电压阈值为1.2kV; E²PROM内容被改写、内RAM被改写较难出现；其它故障现象出现的难易程度相当，最小放电电压在±（2.6-3.6）kV之间。
- 初步实验表明，正负极性静电放电对单片机的影响没有明显差别。

单片机系统ESD电磁脉冲效应实验结果

故障现象		干扰电压阈值	原因分析
重启动		+3.0kV/-3.0kV	RST脚出现持续时间大于一个机器周期的干扰， ESD EMP使CPU内部程序指针PC指向程序起始处。
死机		+3.0kV/-3.0kV	ESD EMP改写了CPU内部程序指针PC内容； 在数据线上产生干扰使其读入错误指令。
控制状态改变		+1.2kV/-1.2kV	锁存器74373片选脚ALE脚上感应出脚态电压，将数据线上的干扰信号锁存后改变输出状态。
A/D转换误差增大		+2.9kV/-2.9kV	引起电源电压波动、改变A/D8809通道或在模拟输入端、数据线上产生干扰。
串行通讯出错		+3.0kV/-3.0kV	出现在EXD线上的ESD EMP干扰被当做数据接收。
外RAM	被改写	+2.6kV/-2.6kV	ESD EMP干扰使程序跳转到写操作代码段； 将数据线上感应的ESD EMP信号当做数据写入RAM； 将数据线上有干扰的错误数据读入CPU。
	写出错	+3.0kV/-3.0kV	
	读出错	+3.2kV/-3.2kV	
工作寄存器被改写		+3.5kV/-3.5kV	干扰进入CPU内部直接改写了内RAM的内容； 干扰直接改写了CPU内部程序状态字PSW的内容。
内RAM被改写		+6.0kV/-5.0kV	
SFR被改写		+3.6kV/-3.6kV	
定时/计数器停止		+3.0kV/-3.0kV	ESD EMP改写了CPU内部PC内容或在数据线上产生错误的地址代码和程序代码而引起程序混乱转。
触发外中断		+2.9kV/-2.9kV	中断申请脚上的干扰信号被误认为是申请信号； 改写中断控制寄存器内容。

E2PROM内容被改写现象出现的次数极少，而且被改写的部分都处于程序区。

GPS接收机ESD电磁脉冲效应实验结果

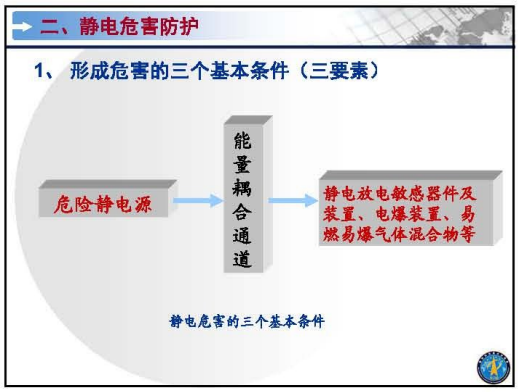
- ESD EMP会干扰XX-A公司生产的 GPS OEM板的正常定位；
- XX-B公司生产的GPS25 OEM板在ESD EMP干扰条件下虽然能够正常定位，但是ESD EMP会干扰GPS OEM板的定位秒脉冲。
- 采用人体金属ESD模型、水平耦合板、接触式放电时，对秒脉冲的影响最大，2.5kV的放电电压就可以对秒脉冲信号造成干扰。

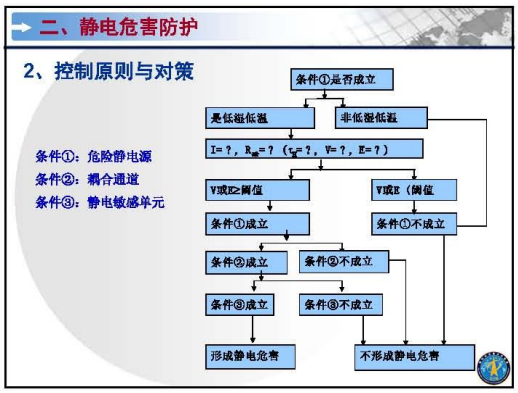
静电会影响电子产品质量等。

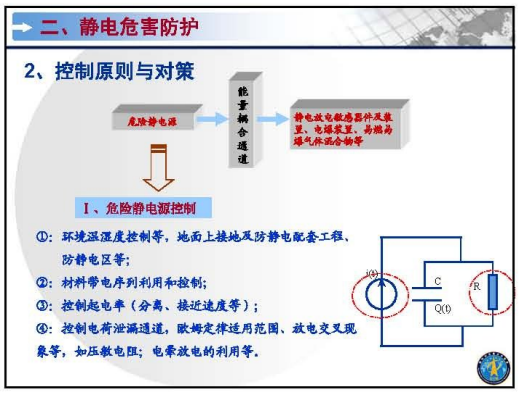
随着电子工业的发展，半导体集成电路的集成度不断提高、功耗越来越低，电路的工作频率大大提高，导致电子设备对静电放电的作用越来越敏感，由静电放电危害造成的损失逐年增加。

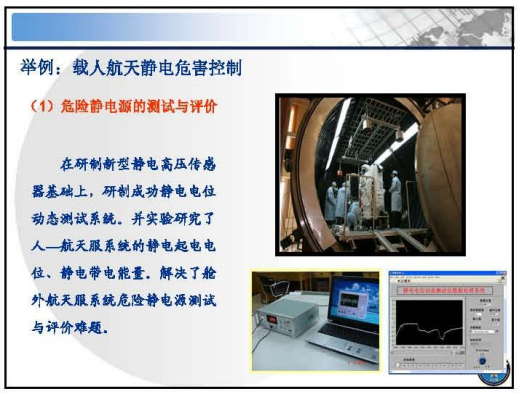
静电会导致半导体生产企业、MOS中测间的成品率下降。在微电子领域，静电造成的损失全球每年高达数百亿美元。


二、静电危害防护


二、静电危害防护
1、 形成危害的三个基本条件（三要素）
危险静电源
能量耦合通道
静电放电敏感器件及装置、电爆装置、易燃易爆气体混合物等
静电危害的三个基本条件


二、静电危害防护
2、控制原则与对策
条件①：危险静电源
条件②：耦合通道
条件③：静电敏感单元
条件①是否成立
是低湿低温
非低湿低温
I=？，R=？（V=？，V=？，E=？）
V或E≥阈值
V或E＜阈值
条件①成立
条件①不成立
条件②成立
条件②不成立
条件③成立
条件③不成立
形成静电危害
不形成静电危害


二、静电危害防护
2、控制原则与对策
危险静电源
能量耦合通道
静电放电敏感器件及装置、电爆装置、易燃易爆气体混合物等
Ⅰ、危险静电源控制
①：环境湿度控制等，地面上接地及防静电配套工程、防静电区等；
②：材料带电序列利用和控制；
③：控制起电率（分离、接近速度等）；
④：控制电荷泄漏通道，欧姆定律适用范围、放电交叉现象等，如压敏电阻；电晕放电的利用等。
I(t)
C
R
Q(t)


举例：载人航天静电危害控制
（1）危险静电源的测试与评价
在研制新型静电高压传感器基础上，研制成功静电电位动态测试系统。并实验研究了人—航天服系统的静电起电电位、静电带电能量。解决了舱外航天服系统危险静电源测试与评价难题。


载人航天静电危害控制：
（2）纯氧环境下材料静电性能评价
为模拟真实使用环境，确定纯氧对材料固有静电性能的影响，研制了纯氧环境静电性能测试装置，并试验确定了纯氧环境舱外航天服材料的静电性能，为合理选择航天服材料提供了依据。
纯氧环境静电性能测试装置
静电与电磁防护研究所

载人航天静电危害控制：

（3）高压纯氧环境下静电放电引燃性评价

克服高压密封条件下静电放电、被试样品、温湿度环境调控等技术难题，研制成功高压纯氧环境静电点火能试验系统，在三种纯氧压力环境下，测定了航天材料的最小静电点火能，解决了舱外航天服系统纯氧环境静电放电引燃性评估难题。

二、静电危害防护

2、控制原则与对策

危险静电源 → 能量耦合通道 → 静电放电敏感器件及装置、电爆装置、易燃易爆气体混合物等

Ⅱ、能量耦合通道控制

和EMC、电磁防护要求一致，隔离、瞬态抑制器件使用、滤波电路等；防绝热过程，采用热平衡措施等；

二、静电危害防护

2、控制原则与对策

危险静电源 → 能量耦合通道 → 静电放电敏感器件及装置、电爆装置、易燃易爆气体混合物等

Ⅲ、提高静电敏感单元的抗静电能力

①：使用抗静电器件、电爆火工品等；

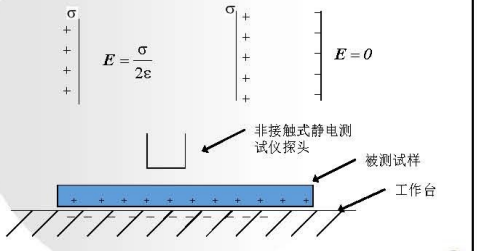
②：对电路进行ESD防护加固（半导体器件设计）；

③：根据IEC61000-4-2对设备进行ESD试验、加固。

三、静电测试与评价中应注意的几个问题

三、静电测试与评价中应注意的几个问题

1、非接触电压测试



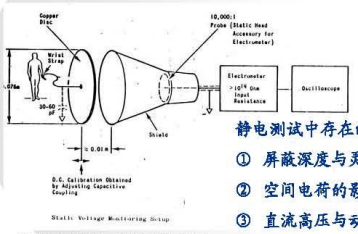
三、静电测试与评价中应注意的几个问题

1、非接触电压测试

非接触电压测试视频

三、静电测试与评价中应注意的几个问题

2、动态电压测试



美国的人体静电测试仪测试原理图

静电测试中存在的问题：

① 屏蔽深度与灵敏度的矛盾

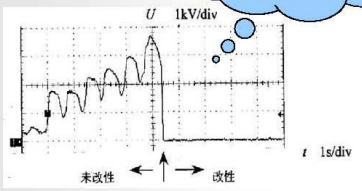
② 空间电荷的影响

③ 直流高压与动态特性的矛盾

针对静电测试中存在的问题，提出了信号自屏蔽电荷耦合测试新原理，研制成功ZPD-1静电电位动态测试仪。

静电动态电位测试演示

人在普通地面、防静电地面上行走时的静电起电情况对比



三、静电测试与评价中应注意的几个问题

3、材料电阻随场强的变化（欧姆定律一般表达式）

静电放电一般不遵循通常意义下的欧姆定律

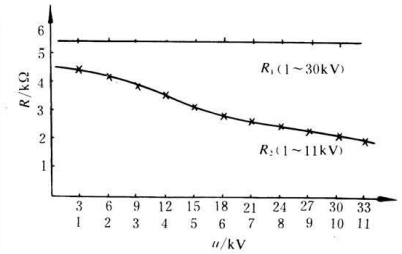
常用公式： $J=\sigma E$

一般表达式：

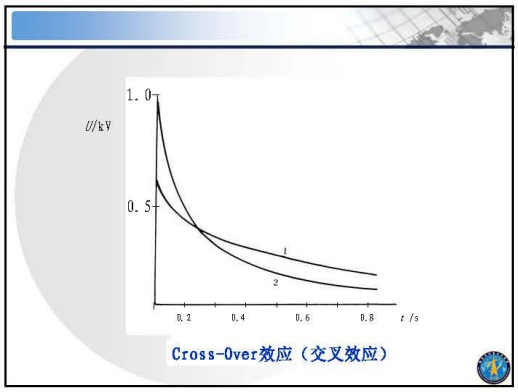
$$J=\frac{2e^2}{kT}\int\tau\ \boldsymbol{v}(k)[\boldsymbol{v}(k)\bullet E]\cdot f_0(1-f_0)dk$$

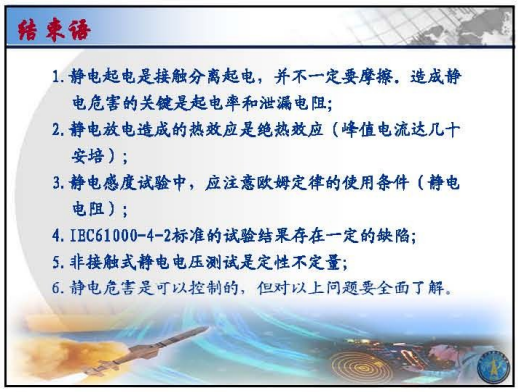
$$+\frac{2e^2}{kTh}\int\tau\ \boldsymbol{v}(k)\{\tau E\bullet\nabla_k[\tau E\bullet\boldsymbol{v}(k)f_0(1-f_0)]\}dk+\cdots$$

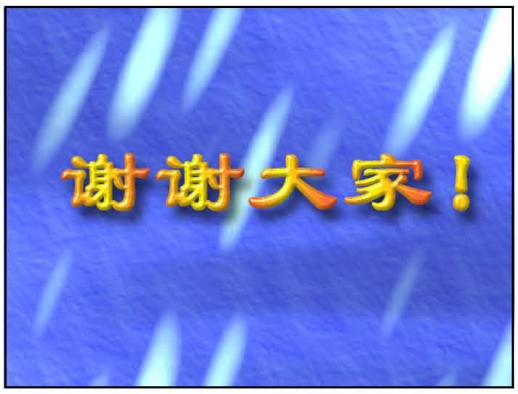
$$+\frac{n\lambda^2\nu\cdot e^2E}{kT}\exp(-\varepsilon/kT)\left(1+\frac{e^2E^2\lambda^2}{24k^2T^2}+\cdots\right)$$



水电阻R_1与碳质实芯电阻R_2的阻值随电压的变化关系


1.0
U/kV
0.5
1
2
0.2
0.4
0.6
0.8
t /s
Cross-Over效应（交叉效应）


结束语
1. 静电起电是接触分离起电，并不一定要摩擦。造成静电危害的关键是起电率和泄漏电阻；
2. 静电放电造成的热效应是绝热效应（峰值电流达几十安培）；
3. 静电感度试验中，应注意欧姆定律的使用条件（静电电阻）；
4. IEC61000-4-2标准的试验结果存在一定的缺陷；
5. 非接触式静电电压测试是定性不定量；
6. 静电危害是可以控制的，但对以上问题要全面了解。


谢谢大家！

The Hazard and Protection of Electrostatic

Liu Shanghe

State-level Key Laboratory of Electromagnetic Environment Effects
(Electrostatic and Electromagnetic Protection Research Institute of Ordnance Engineering College)

Main content in the lecture

I. Features of electrostatic discharge and electrostatic hazards

II. Electrostatic Hazards and Protection

III. Problems which shall be focused on in the electrostatic test and assessment

IV. Conclusion

I. Features of electrostatic discharge and electrostatic hazards

I. Features of electrostatic discharge and electrostatic hazards

1. Features of electrostatic discharge

Electrostatic discharge could form:

- High potential, strong electrical field
- Transient large current
- Broadband electromagnetic interference

I. Features of electrostatic discharge and electrostatic hazards

1. Features of electrostatic discharge

Electrostatic discharge could form:

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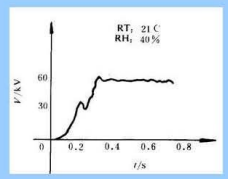


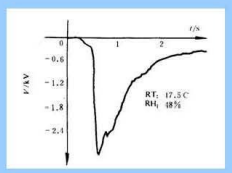
Electrification waveform of human body when wearing the nylon silk cotton and orlon short overcoat with internal hair, wearing the cloth shoes with red plastic bottom on the dry ground, and taking off short coat.

I. Features of electrostatic discharge and electrostatic hazards

1. Features of electrostatic discharge

Electrostatic discharge could form:

- High potential, strong electrical field
- Transient large current
- Broadband electromagnetic interference



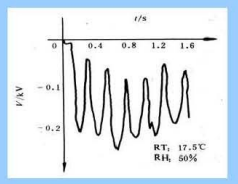
Waveform of human body electrification and discharge when person sits on the suede electroplating chair, wears anti-static shoes and suddenly stands up on wood floor

I. Features of electrostatic discharge and electrostatic hazards

1. Features of electrostatic discharge

Electrostatic discharge could form:

- High potential, strong electrical field
- Transient large current
- Broadband electromagnetic interference



Transient potential waveform of human body when person wears red plastic slippers and walks on cement painting ground

I. Features of electrostatic discharge and electrostatic hazards

1. Features of electrostatic discharge

Electrostatic discharge could form:

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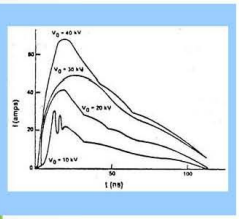
- Transient large current
- Broadband electromagnetic interference



I. Features of electrostatic discharge and electrostatic hazards

Typical case that transient large current of electrostatic discharge cause malfunction of foreign satellite

Fault of attitude control computer of France communication satellite

France communication satellite Telecom-1B causes the fault of main and backup attitude control computer of the satellite and the satellite failure due to the electromagnetic pulse and coupling generated from electrostatic discharge (momentary value reaches dozens of ampere) into the satellite.

All Telecom-1B satellite attitude control computers malfunction

I. Features of electrostatic discharge and electrostatic hazards

1. Features of electrostatic discharge

Electrostatic discharge could form:

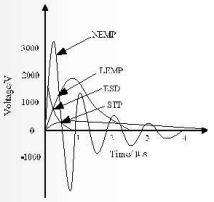
- High potential, strong electrical field
- Transient large current
- Broadband electromagnetic interference

The electromagnetic effect radiation field generated in the process of electrostatic discharge covers very wide spectral range, some reach 0~3GHz by report.

I. Features of electrostatic discharge and electrostatic hazards

1. Features of electrostatic discharge

As the near field hazard sources, the electromagnetic pulse effects generated from electrostatic discharge could be compared with effects of LEMP, HEMP or STP.



I. Features of electrostatic discharge and electrostatic hazards

2. Effects of hazard formation

- Mechanical effect
- Heat effect
- Electromagnetic radiation effect
- Strong electrical field effect
- Magnetic effect

I. Features of electrostatic discharge and electrostatic hazards

2. Effects of hazard formation

- Mechanical effect
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- Magnetic effect

Electrostatic field makes the material particle polarize, thus generate the electrostatic attraction, then dust suspended in air is easily adsorbed in article to generate pollution. In case the semiconductor chip takes static electricity, the dust could be adsorbed in chip, which can decrease rate of finished product of integrated circuit greatly.

The coulombian force of electrostatic field makes automatic production lines such as textile, printing, plastic package, etc. hindered.

I. Features of electrostatic discharge and electrostatic hazards

2. Effects of hazard formation

- Mechanical effect
- Heat effect
- Electromagnetic radiation effect
- Strong electrical field effect
- Magnetic effect

The heat effect generated from electrostatic discharge is a kind of adiabatic process completed in ns or s magnitude. As the ignition source and detonation source, it could transiently generate the combustion explosion of flammable and explosive gas, electric explosive device, etc. It could make the microelectronic device and electromagnetic sensitive circuits superheat, then causes the partial thermal damage, and circuit performance deterioration or failure.

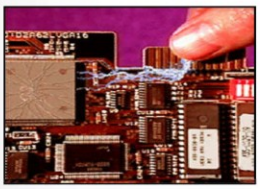
Adiabatic effect

S/N	Model Name	Resistance/	Ignition conditions	Safety conditions		50% firing energy/mJ
				I/mA	t/s	
1	JD-11 electric igniter	1.25~2.25	700mA	180	5~10	1.73
2	JD-1 electric igniter	0.15~0.80	6V	150	300	12.0
3	DD-4.5 electric ignitron	2.5~4.5	400mA	50	300	1.00
4	DD-17 electric ignitron	12~17	500mA	25	30	0.225
5	105 electric primer	15~60	24Vserial 4	0.1F,45V		0.270

Take JD-11 electric igniter for example: Its security energy is calculated as 729mJ, while 50% firing energy is only 1.73mJ under the pulse action.
The security energy of JD-1 electric igniter is 5.4J, while it's 50% under the pulse action and the firing energy is only 12mJ.

Hazard of adiabatic effect to circuit

Random EMP is generally completed at the microsecond or sodium seconds magnitude, therefore it's a kind of adiabatic process. For microelectronic device, the discharge energy is released through the device resistance within 0.1μ. Its average power could reach several thousand kilowatts and form a large temperature gradient within the device, causing the partial thermal damage.



Mode that ESD heat effect causes microelectronic circuit damage

ESD heat effect

- The metal wiring and diffusion zone (or polycrystal) contact hole generate the spark, which make the ohmic contact of metal and silicon damaged.
- Partial silicon is fused, then the recrystallization is generated to produce device short circuit.
- The metallization electrode and wiring fusion and "nodulizing" cause the open-circuit.
- Large current flows through the PN junction and generates the joule heat, then the junction temperature rises and forms the "heat spot" and "thermal runway", causing in damage of device.

Typical case that heat effect of electrostatic discharge causes malfunction of foreign satellite

- The power line of Japanese earth observation satellite is burned

When the Japanese earth observation satellite (ADEOS-II) passes through the polar regions, the internal charging effect incurred by the high-energy electron burns the part of electricity cable between the solar arrays and satellite, which causes that the satellite power reduces to 1KW from 6KW, and the most of satellite functions lose.

The power line of ADEOS-II satellite is burned

I. Features of electrostatic discharge and electrostatic hazards

2. Effects of hazard formation

- Mechanical effect
- Heat effect
- Electromagnetic radiation effect
- Strong electrical field effect
- Magnetic effect

The radio-frequency interference incurred by electrostatic discharge causes electrical noise and electromagnetic interference to information devices, and makes information devices malfunction or loss function. Strong electromagnetic pulse could form the accumulative effects, which could cause the performance parameter of the device or circuit degradate or complete failure, and reduce the reliability of circuit or equipment.

I. Features of electrostatic discharge and electrostatic hazards

2. Effects of hazard formation

- Mechanical effect
- Heat effect
- Electromagnetic radiation effect
- Strong electrical field effect
- Magnetic effect

The strong electrical field formed by electrostatic hazard sources could break through the gate oxide of MOS field-effect device or the media between the metal, which causes the circuit failure. This asks for higher requirements to the electric insulation. The strong electrical field could also form potential failure.

Mode that ESD strong electrical field effect causes microelectronic circuit damage

ong electrical field effect of ESD

The strong electrical field causes the breakthrough gate oxide of MOS field-effect device and the device failure.

The strong electrical field causes the breakthrough of micro-electronics circuit insulation medium or the performance reduction of the device.

The strong electrical field makes the integrated circuit component and precise electronic component aging, and reduces the equipment service life.

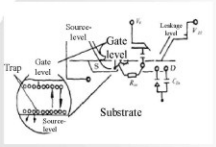
Typical case that strong electrical field of electrostatic discharge causes malfunction of foreign satellite

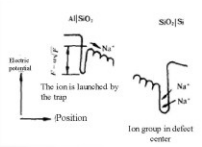
- Cable breakdown of America national defense communication satellite

Since the electrostatic voltage of America national defense communication satellite DSCS-II (9431) on the surface of cable exceeds the 130% cable breakdown threshold value, the power supply cable of a communication system is broken through, which causes the satellite failure.

The cable breakdown happened to DSCS-II satellite

Potential hazards

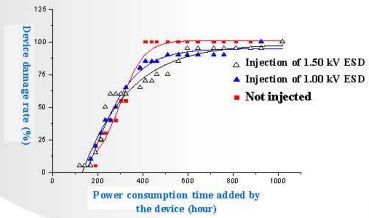




When the electric field is additionally added to MOS device grid electrode, in case the grid electrode isn't broken through under the electric field function, Na+ ion at the Al/SiO 2 interface in SiO2 film could be clustered at the defect center of SiO/2Si surface by drift, which buries hidden trouble for the partial breakthrough during the device usage and causes potential hazards.

Potential hazards

◆EMP could cause the potential failure related to time to part of devices, but there are also parts of devices whose service life is slightly improved.



1. Features of electrostatic discharge and electrostatic hazards

2. Effects of hazard formation

- Mechanical effect
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- Strong electrical field effect
- Magnetic effect

The strong current incurred by electrostatic discharge could generate the strong magnetic field to disturb the normal work of electronic equipment. Therefore the design of information devices and selection of magnetic shielding materials have stringent requirements.

1. Features of electrostatic discharge and electrostatic hazards

3. Hazard examples

(1) Electrostatic discharge causes the fault of foreign satellites

S/N	Satellites	Fault	Damage position
1	America DSCS-II(9431) satellite	Communication system source is interrupted with the satellite failure	
2	Japan ADEOS-II satellite	The cable between solar array and satellite subject is burned with power reduction and function loss	
3	Arabia satellite communication organization Arabsat-1A satellite	With the fault of energy system, the satellite is transferred into standby satellite	
4	European Space Agency MARECS-A satellite	The solar array is burned up with the power reduction, and the satellite service is terminated	Energy system
5	European Space Agency Meteosat-F1 satellite	Fault occurs in the energy system	
6	Japan ETS-6 satellite	Solar battery bus is broken through with the power reduction	
7	Canada - America CTS satellite	The power diode loses efficacy, which causes one electric power bus is burned	
8	America DSCS-II (9432) satellite	Energy system is continuously abnormal with satellite failure.	
9	European Space Agency Meteosat-F2 satellite	Fault occurs in the energy system	
10	France Telecom-1B satellite	Main backup attitude control system has a fault with satellite failure	
11	America Intelsat K satellite	Momentum wheel control circuit has a fault	
12	Canada Anik E-1 satellite	The fault of gyroscope	Electronic system
13	Canada Anik E-2 satellite	All main backup attitude control systems have a fault with satellite failure	
14	America Telstar 401 satellite	Attitude control system fault	
15	America Intelsat K satellite	Momentum wheel control circuit has a fault	
16	America HAT0-3A satellite	Attitude control system fault	

3. Hazard example

Electrostatic discharge causes the fault of foreign satellites (continued table)

S/N	Satellites	Fault	Damage position
17	Japan BS-3A satellite	60-minute remote recording loses	
18	Australia AUSSAT-A3 satellite	Fault of attitude control system remote measuring switch	
19	America FLTSATCOM 6071 satellite	Five times logical errors happen	
20	Australia AUSSAT-A2 satellite	Attitude control system fault	
21	Australia AUSSAT-A1 satellite	Attitude control system fault	
22	America Intelsat K-511 satellite	Attitude control system fault	
23	America Telstar 401 satellite	Attitude control system fault	
24	America Intelsat 510 satellite	Attitude control system fault	Electronic system
25	Canada Anik D-2 satellite	The despun control system has a fault with communication interruption.	
26	France Telecom-1A satellite	With communication fault, the satellite is transferred to backup satellite.	
27	America TDRS-1 satellite	Control system fault	
28	America TDRS-3 satellite	Circuit fault of attitude control system processor	
29	America TDRS-4 satellite	Attitude control system fault	
30	America TDRS-5 satellite	Attitude control system fault	
31	America SBS-1 satellite	Circuit fault of attitude control system	
32	America DSCS-II (9443) satellite	Logical error	

3. Hazard example

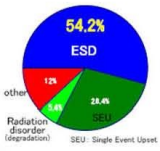
Electrostatic discharge causes the fault of foreign satellites (continued table)

S/N	Satellites	Fault	Damage position
33	America HAT0-3C satellite	Attitude control system fault	
34	America HAT0-3B satellite	The attitude control system has a fault with abnormal instruction.	
35	America DSCS-II (9438) satellite	Logical error	
36	America DSCS-II (9442) satellite	Logical error	Electronic system
37	France-Germany Symphonie A/B satellite	Logic reversal	
38	Britain Skynet 2B satellite	Circuit fault of remote metering and control system	
39	America IEES satellite	Instruction unit work is abnormal	
40	America DSCS-III (4534) satellite	Rotating speed test system fault	
41	Japan GMS-4 satellite	Fault of infrared visible scanning radiometer	
42	Japan GMS-3 satellite	Abnormal accelerometer, and fault of infrared visible scanning radiometer	
43	America GOES-6 satellite	X-ray sensor fault	
44	America GOES-4 satellite	Radiometer and Atmosphere Detector Loss Efficacy, and the Satellite Service Terminates	
45	America SCATHA satellite	With data loss, both magnetic field detector and plasma analysis meter have fault	
46	America Viking Lander 1 satellite	mass spectrograph abnormally works	
47	Canada Anik B-1 satellite	Performance of thermal control losting reduces	Function Material
48	America Landsat-3 satellite	Sensor pollution aggravates	

3. Hazard example

Foreign statistics indicate that: Electrostatic discharge is the main reason which causes the satellite failure

NASA statistics of 4 authorities' database in 2007 indicates that electrostatic discharge effect accounts for 54.2% in the 326 foreign satellite faults incurred in space environment.



Scale drawing of foreign space environment fault

Sources of Data

(1) Spacecraft Anomaly Manager (SAM). This database is maintained by NOAA/NGDC in Boulder, Colorado. This database primarily contains anomalies that are believed to have been caused by the space environment.

(2) NASA Anomaly Reports [*Bedingfield et al.*, 1996; *Leach and Alexander*, 1997].

(3) The anomaly database maintained by the US Air Force 55th Space Weather Squadron.

(4) Individual Program Offices databases.

Reference

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(2) Statistical table of failure for rocket flight

S/N	Rocket Name	Flight test code	Launching Time	Height/km	Vacuum degree/mmHg	Fault profiles and reasons
1	Militia I	FTM-502	1962	7.6	316	Electrostatic discharge causes the fault of guidance computer, Class I engine has self-destruction before closing with failure launching
2	Militia I	FTM-503	1962	21.8	39.6	Electrostatic discharge causes the fault of guidance computer, Class I engine has self-destruction before closing with failure launching
3	Ouluoni II	F-11	1971	27	7.94	Electrostatic discharge makes the guidance computer blocked with attitude out of control,then the Class I and II rockets have self-destruction due to overload after about one minute, so the launching fails
4	Scout	S-112	1964	38-42	3.09-1.86	Parts between the electric squib igniter wire and shell is broken through by an electric arc; the self-destruction system of Class II engine explodes with failure launching
5	Scout	5128	1964	38-42	3.09-1.86	Parts between the electric squib igniter wire and shell is broken through by an electric arc; the self-destruction system of Class II engine explodes with failure launching
6	Titan ⅢC	C-10	1967	26	8.94	Electrostatic discharge lets the guidance computer automatically transfer to the emergency backup state after fault
7	Titan ⅢC	C-14	1967	17	52	Electrostatic discharge lets the guidance computer be amended to the pre-selected orbit after fault with the ground launch instruction
8	Deeran	2313	1974			Guidance system control devices have faults, and the rocket fails in launching due to tumbling

3. Hazard example

(3) Hazards of static electricity to aircraft fuel system

Since the fuel system grounding is incorrect and human body doesn't adopt the anti static precautions upon the maintenance of F-15 warcraft, electrostatic discharge causes the complete destruction of the aircraft.

3. Hazard example

(4) Hazard of static electricity to electronic system

Experimental result of single-chip system ESD electromagnetic pulse effect

- ESD EMP could generate interference to the single-chip system working under various procedure models, and the control status is most likely to appear of all fault phenomenon. The disturbance voltage threshold value for discharge of vertical coupling plate of human body metal pattern is 1.2kV; It's more difficult to rewrite the E^2PROM content and internal RAM; Other fault phenomenon have the same occurrence rate, and the minimum discharge voltage is between 2.6 kV and 3.6 kV.
- The preliminary experiment indicates that electrostatic discharge of positive and negative polarity has no obvious difference influence to the single-chip processor.

Experimental results of ESD electromagnetic pulse effect of single-chip system

Fault phenomenon		Disturbance voltage threshold value	Cause analysis
Restart		+3.0kV/-3.0kV	The interference whose continuous time is larger than one machine cycle occurs to the RST foot ESD EMP lets the internal procedures pointer of CPU point to the procedure beginning location.
Crash		+3.0kV/-3.0kV	ESD EMP rewrites the content of internal procedure pointer PC of CPU. Disturb the data cable, and let data cable sudin false instructions.
Change of control status		+1.2kV/-1.2kV	Latch 74373 Chip Selection and ALE foot induce the transient voltage, then the output status is changed after the interference signal on data cable is latched.
A/D transfer error increases		+2.9kV/-2.9kV	Cause the supply voltage fluctuation, change A/D0809 channel or cause the disturbance to simulation input terminal and data cable.
Serial communications malfunction		+3.0kV/-3.0kV	The ESD EMP disturbance occurred on RXD line is regarded as the data reception.
Exterior window.	Be rewritten	+2.6kV/-2.6kV	ESD EMP disturbance lets the procedure skip to the operation code segment for writing; Read the ESD EMP signal induced on data cable in RAM as data; Read the disturbance error on data cable in CPU.
	Writing error	+3.0kV/-3.0kV	
	Reading error	+3.2kV/-3.2kV	
work register is rewritten		+3.5kV/-3.5kV	Disturbance is directly rewritten as internal RAM content after entering in the CPU; Disturbance directly rewrites the status word PSW content of internal CPU.
Internal RAM is rewritten.		+5.0kV/-5.0kV	
SFR is rewritten		+3.6kV/-3.6kV	
Timer/counter stops		+3.0kV/-3.0kV	ESD EMP rewrites the PC content of internal CPU or generates the false address code and procedure on data cable, which causes the false jumping of procedure.
Trigger external interruption		+2.9kV/-2.9kV	Interruption of disturbance signal on application foot is mistakenly regarded as signal application; Rewrite the content in the interrupt control register.

The times for E2PROM content to be rewritten is few, and the part rewritten is in the procedure area.

Experimental result for ESD electromagnetic pulse effect of GPS receiver

- ESD EMP would interrupt the normal position of GPS OEM plate produced by XX-A company;
- Although the GPS25 OEM plate produced by XX-B company could normally position under the ESD EMP disturbance condition, ESD EMP could disturb the pulse per second of GPS OEM plate.
- ESD electromagnetic pulse effect has the largest influence to pulse per second when the human body metal ESD model, horizontal coupling plate and contact-type discharge are adopted, and 2.5kV discharge voltage could generate the disturbance to the pulse per second signal.

Static electricity would influence the quality of electronic products, etc.

With the development of electronic industry, the integration level of semiconductor integrated circuit constantly improves, while power becomes lower and lower and working frequency of the circuit greatly improves, which cause the electronic equipment become more and more sensitive to electrostatic discharge, and the loss incurred by electrostatic discharge increases year by year.

Static electricity could cause the reduction of enterprise' semiconductor manufacturing and finished product ratio of MOS. The loss incurred by static electricity reaches USD several hundred million globally annually in micro-electronics field.

II. Electrostatic Hazards and Protection

II. Electrostatic Hazards and Protection

1. Three basic conditions (three elements) forming hazard

Dangerous electrostatic source → Energy coupling channel → ESDS, electric explosive device, flammable and explosive gas mixture, etc.

Three basic conditions of electrostatic hazard

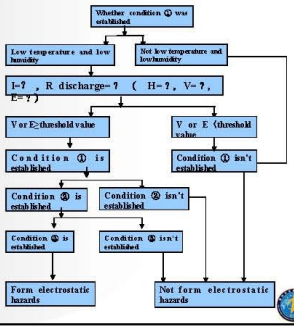
II. Electrostatic Hazards and Protection

2. Control principle and countermeasure

Condition①: Dangerous electrostatic source

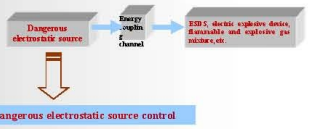
Condition ②: Coupling channel

Condition ③: Electrostatic-sensitive unit



II. Electrostatic Hazards and Protection

2. Control principle and countermeasure



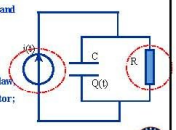
Ⅰ. Dangerous electrostatic source control

①: Control of environment temperature and humidity, grounding and anti-static supporting engineering, EPA, etc.

②: Utilization and control of charge sequence of materials;

③: Control of electrification rate (separation, closing speed, etc.);

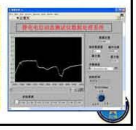
④: Control of charge leakage channel, applicable scope of Ohm's law, inter-related phenomenon of discharge, etc. such as piezoresistor; Utilization of brush discharge, etc.



Examples: Control of electrostatic hazard of manned space flight

(1) Test and evaluation of dangerous electrostatic source

Successfully develop the dynamic test system of electrostatic potential on the basis of researching of the new-style electrostatic high-pressure transducer. Conduct research on electrostatic potential of person-space suit system and electrostatic charged energy. Solve the test and evaluation problems for dangerous electrostatic source of outboard space suit system.



Control of electrostatic hazard of manned space flight

(2) Evaluation of material electrostatic performance under the pure oxygen environment

In order to simulate the actual use environment and confirm the influence of pure oxygen to inherent electrostatic property of material, the device for electrostatic performance test under pure oxygen environment is developed, and the electrostatic performance of outboard space suit material under pure oxygen environment is confirmed with test, which provide the basis for reasonably selecting the space suit material.

Control of electrostatic hazard of manned space flight

(3) Evaluation of electrostatic discharge ignition under high-pressure pure oxygen environment

The electrostatic ignition energy test system of high-pressure pure oxygen environment is successfully developed when overcoming the electrostatic discharge, the sample tested, control of temperature and humidity environment and other technological problems. The minimum fire energy of aerospace materials at electrostatic point is measured under the environment of three pure oxygen pressure to solve the electrostatic discharge ignition evaluation problem of outboard space suit system under the pure oxygen environment.

II. Electrostatic Hazards and Protection

2. Control principle and countermeasure

Ⅱ. Control of energy coupling channel

Consistent with the requirement of EMC and electromagnetic protection, usage of the device for isolation and transient suppression and the filter circuit; Heat balance measures and other measures are adopted during the adiabatic process;

2. Control principle and countermeasure

III. Improve the antistatic ability of electrostatic sensing unit

①: Use the antistatic device, electric explosive device, etc.

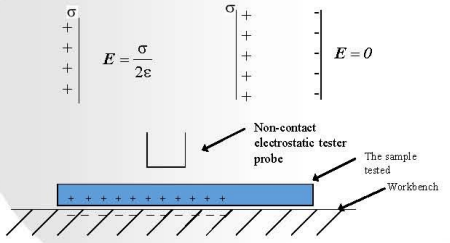
②: Conduct the ESD protection and reinforcement (design of semiconductor device) to circuit;

③: Conduct ESD test and reinforcement to equipment according to IEC61000-4-2.

III. Problems which shall be focused on in the electrostatic test and assessment

III. Problems which shall be focused on in the electrostatic test and assessment

1. Non-contact voltage test



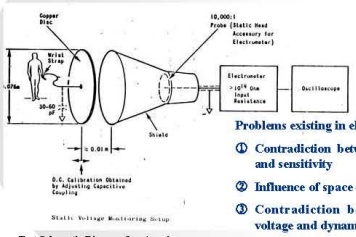
III. Problems which shall be focused on in the electrostatic test and assessment

1. Non-contact voltage test

Video of non-contact voltage test

III. Problems which shall be focused on in the electrostatic test and assessment

2. Dynamic voltage test



Problems existing in electrostatic test:

① Contradiction between shielding depth and sensitivity

② Influence of space charge

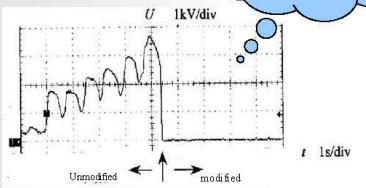
③ Contradiction between high direct voltage and dynamic performance

Test Schematic Diagram for American Human Body Electrostatic Tester

The theory of signal self-shielding in charge coupling test is proposed to solve problems existing in the electrostatic test, and successfully develop the ZPD-1 electrostatic potential dynamic tester.

Demonstration of electrostatic dynamic potential test

Comparison of electrostatic discharge when walking on comme ground and anti-static ground respectively.



III. Problems which shall be focused on in the electrostatic test and assessment

3. Change of material resistance along with the strong field (general formula of Ohm's law)

Electrostatic discharge doesn't comply with the Ohm's law from common sense in general

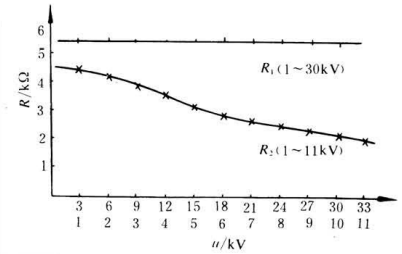
Conventional formula: $J = \sigma E$

General formula:

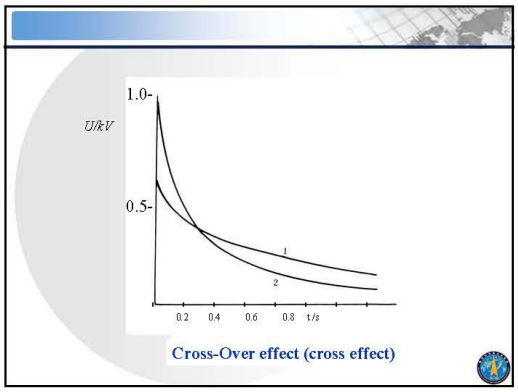
$$J = \frac{2e^2}{kT}\int \tau\ \boldsymbol{v}(k)\left[\boldsymbol{v}(k)\bullet E\right]\cdot f_0(1-f_0)dk$$

$$+\frac{2e^2}{kTh}\int \tau\ \boldsymbol{v}(k)\{\tau E\bullet\nabla_k[\tau E\bullet\boldsymbol{v}(k)f_0(1-f_0)]\}dk+\cdots$$

$$+\frac{n\lambda^2\ \nu\cdot e^2E}{kT}\exp(-\varepsilon/kT)\left(1+\frac{e^2E^2\lambda^2}{24k^2T^2}+\cdots\right)$$



Change relation of resistance value of resistance R_1 and carbon solid core resistance R_2 along with the voltage


1.0-
U/kV
0.5-
1
2
0.2
0.4
0.6
0.8
t/s
Cross-Over effect (cross effect)


Conclusions
1. Electrostatic discharge refers to electrification caused by contact and separation, which doesn't have to be caused from friction. The key factors causing the electrostatic hazards are charge rate and leakage resistance;
2. Heat effect incurred by electrostatic discharge is adiabatic effect (peak current reaches dozens of ampere);
3. The usage condition (electrostatic resistance) of Ohm's law shall be focused on in the electrostatic sensitivity test;
4. The test result of IEC61000-4-2 standard has certain defects;
5. Non-contact electrostatic voltage test is qualitative and non-quantitative;
6. Electrostatic hazard is controllable, but the above problems shall be comprehensively known.


Thank you!

汤万金

汤万金，中国标准化研究院副院长，研究员，博士，享受政府津贴待遇。毕业于北京科技大学获博士学位，中国科学院博士后。作为专家组组长全面参与国家标准化改革方案设计。担任多个技术委员会秘书长、副主任和发改委服务专家委员会、新疆政府专家。近年负责完成 2 项国家自然科学基金，主持或参与 10 余项国家“九五”、“十五”、“十一五”攻关课题，负或参与 20 余项部委科研项目；负责或参与多项国家标准的研制；在国内外核心期刊发表科技论文 80 余篇，出版著作 6 部。研究成果获省部级 10 余项奖励。

Tang Wanjin

Tang Wanjin, the vice president, researcher and Ph.D. of China National Institute of Standardization, enjoys government subsidies. He received his doctor's degree from University of Science and Technology Beijing and post doctor's degree from Chinese Academy of Sciences. As the leader of Expert Group, he participates in the design of the reform scheme for national standardization. He also holds the post of secretary-general or vice chairman in many technical committees and also works for the Committee of Service Experts under National Development and Reform Commission. He is also specially hired as the government expert of Xinjiang autonomous region. In recent years, he has completed 2 items of Natural Science Foundation of China, hosted or participated in more than 10 national projects including "the ninth Five-Year plan", "the Tenth Five-Year Plan" and "the 11th Five-Year Plan". He is responsible for or participates in over 20 ministry or commission level research projects and the reparation and compilation of many national standards. He has published over 80 papers in the domestic and oversea core technical journals and 6 academic works. His research achievements have been conferred with 10 more provincial- and ministerial-level awards.

标准化作用的再认识

中国标准化研究院 汤万金
二〇一六年十一月十七日
•Tangwj@cnis.gov.cn

前言

标准是人类文明进步的成果。标准化在便利经贸往来、支撑产业发展、促进科技进步、规范社会治理中的作用日益凸显。

中国将积极实施标准化战略，以标准助力创新发展、协调发展、绿色发展、开放发展、共享发展。

前言

面对困难和挑战，要保持经济平稳运行，既要保持总需求力度，也要加快推进供给侧结构性改革，着力改善供给质量。这就需要把标准化放在更加突出的位置，以标准全面提升推动产业升级，形成新的竞争优势，促进经济中高速增长、迈向中高端水平。

前言

《国家标准化改革方案》

《国家标准化体系建设发展规划》

《消费品标准与质量提升规划》

《制造业标准与质量提升规划》

介绍内容 CONTENTS

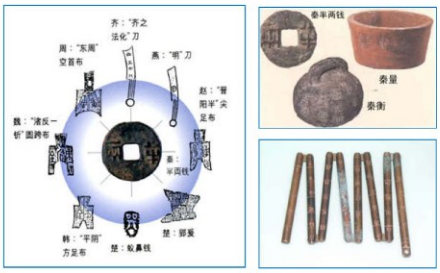
一、标准化的产生与发展

标准化的产生与发展经历 → 古代、近代和现代三个发展阶段

古代标准化 → 从旧石器时代到1782年工业革命开始前

一、标准化的产生与发展

- 秦始皇统一货币、度量衡



一、标准化的产生与发展

- 兵马俑

一、标准化的产生与发展

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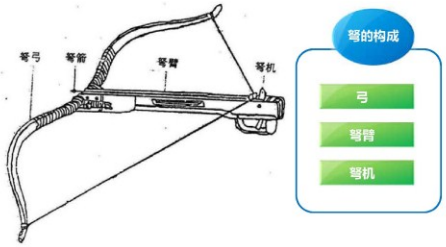
一、标准化的产生与发展

- 兵马俑



一、标准化的产生与发展

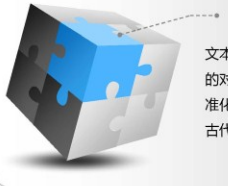
- 兵马俑

考古学家根据《吕氏春秋》中“物勒工名”的记载，考证出秦国军备生产管理制度分为四级：

相邦	就是丞相，相当于今天的国家总理。目前出土的兵器大都刻着秦相吕不韦的名字
工师	个兵工厂的厂长
丞	工厂的生产主任
工匠	实际生产兵器的工人

一、标准化的产生与发展

启示



在我国古代，标准虽然没有以文本形式存在，但却固化到标准化的对象中。标准化思想的启蒙和标准化方法的应用极大地推动了我国古代文明的发展。

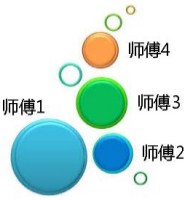
一、标准化的产生与发展

- 近代标准化是从工业革命至20世纪中叶
- 1782年瓦特发明蒸汽机，标志着工业革命的开始

工业革命是生产方式的变化，从原始手工作坊的落后生产方式向机械化规模化生产方式的转变

一、标准化的产生与发展

手工作坊式的生产，是师傅带徒弟，从最开始的设计到最后出产品，师傅负全责，两个师傅生产出来的产品是不一样的



一、标准化的产生与发展

生产力的发展导致企业内部分工，也大大促进了企业内部的标准化

企业内部标准化主要目的是提高生产效率,基本原理主要是利用标准件的互换性。

一、标准化的产生与发展

牛被送进屠宰场后，会先用电击击昏，放血，再吊起来，用电锯开膛剖腹，最后是各个部位的分割，这个过程分别由不同的人来完成。

福特发现：这种流水化作业工作效率高，能运用于汽车制造。

“工人、农民才是真正需要汽车的人。我**主张多按标准化大批量生产,把便宜实用的汽车卖给这些**人。这才是我们公司的长期战略！”

一、标准化的产生与发展

世界第一条汽车流水装配线在福特的工厂诞生。流水线对生产的每道程序,工人的每个动作都制定了标准。

1分钟内生产1辆汽车

10秒钟生产1辆汽车

1913年　1920年　1925年

一、标准化的产生与发展

1914年生产了308,162辆车

超过美国其他299家汽车制造厂生产的总和

1921年，T型车的产量已占世界汽车总产量的56.6%。由福特创建的标准化流水线为后来的汽车工业发展树立了楷模。

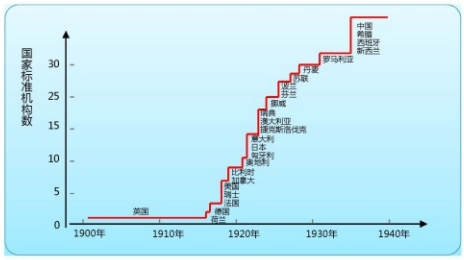
一、标准化的产生与发展

当一个企业不能独立完成一件产品的生产时，企业之间出现了专业化分工，同时也面临着通用性和互换性问题。

出现了对民间标准化组织的需求。

由于生产的发展和协作范围的扩大，使许多标准不仅要求在本行业范围内统一，而且要求跨行业，在全国范围内统一，于是产生了国家标准。与此同时，也出现了国家标准化组织。

一、标准化的产生与发展



1901-1932年国家标准机构的建立速度

一、标准化的产生与发展

启示

标准化对于工业革命所产生的推动作用，正如古典管理学创始人泰勒（Frederick W. Taylor ，1856-1915）在《科学管理原理》中所阐述的一样：

"只有通过坚持采用标准化的方法，坚持进行合作，才能确保更快的工作进度。坚持采用标准并坚持合作是赋予管理的唯一职责。"

一、标准化的产生与发展

现代标准化从20世纪中叶至今

国际贸易的蓬勃开展催生了现代标准化

标准化体现出国际化和系统性的鲜明特点

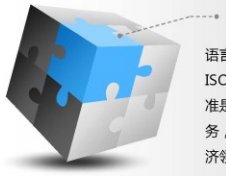
一、标准化的产生与发展

标准类别的形成与发展经过了这样的过程：

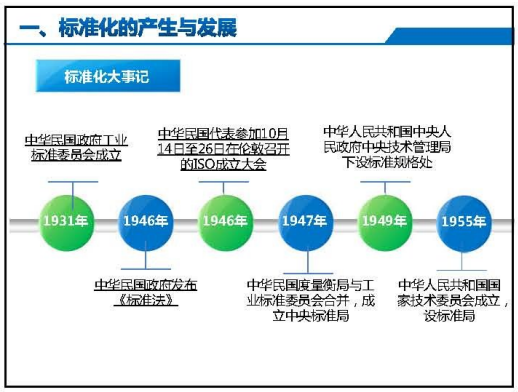
企业标准 → 协会标准 → 国家标准 → 国际标准

一、标准化的产生与发展

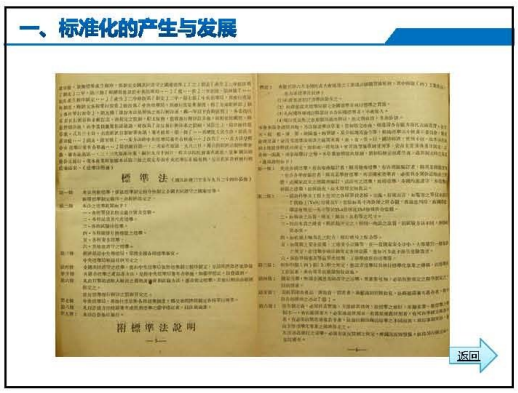
启示



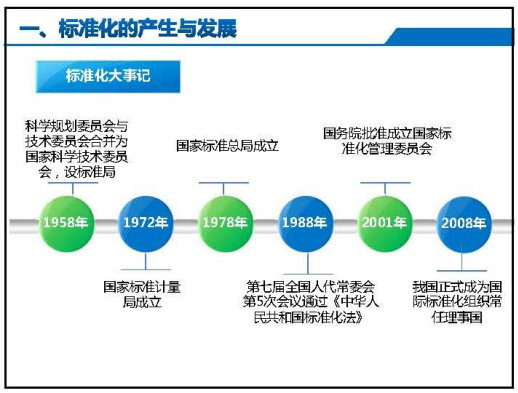
标准成为了国际贸易的“共同语言”，标准所发挥的作用正如ISO在其宗旨中所言，制定国际标准是为了“便于国际物资交流和服务，并扩大知识、科学、技术和经济领域中的合作”。

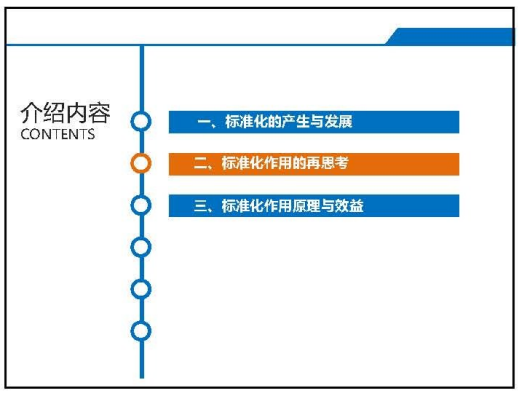

一、标准化的产生与发展
标准化大事记
中华民国政府工业标准委员会成立
1931年
中华民国代表参加10月14日至26日在伦敦召开的ISO成立大会
1946年
中华民国政府发布《标准法》
1946年
中华民国度量衡局与工业标准委员会合并，成立中央标准局
1947年
中华人民共和国中央人民政府中央技术管理局下设标准规格处
1949年
中华人民共和国国家技术委员会成立，设标准局
1955年


一、标准化的产生与发展
工業標準通訊
返回


一、标准化的产生与发展
標準法
附標準法說明
返回


一、标准化的产生与发展
向贤德
返回


一、标准化的产生与发展
标准化大事记
科学规划委员会与技术委员会合并为国家科学技术委员会，设标准局
1958年
国家标准计量局成立
1972年
国家标准总局成立
1978年
第七届全国人代常委会第5次会议通过《中华人民共和国标准化法》
1988年
国务院批准成立国家标准化管理委员会
2001年
我国正式成为国际标准化组织常任理事国
2008年


介绍内容
CONTENTS
一、标准化的产生与发展
二、标准化作用的再思考
三、标准化作用原理与效益

二、标准化作用的再认识

（一）标准与技术创新
（二）标准与产业发展
（三）标准与社会管理
（四）标准化的本质

二、标准化作用的再认识

创新的概念

“创新”概念最先由美籍奥地利经济学家熊比特(J.A.Schumpeter)于1912年最先在德文版《经济发展理论》一书中提出来，成为创新理论研究的鼻祖。在熊比特看来，“创新”不仅是指科学技术上的发明创造，而更是指把已发明的科学技术引入企业之中，形成一种新的生产能力。

二、标准化作用的再认识

创新的概念

熊彼特

“先有发明，后有创新。发明是新工具或新方法的发现，创新是新工具或新方法的实施。”

“只要发明还没有得到实际上的应用，那么在经济上就是不起作用的。”

二、标准化作用的再认识

创新的概念

美国经济学家曼斯费尔德(E.Mansfield)认为，创新就是“Innovation is the first application of invention”(一项发明的首次应用)。

二、标准化作用的再认识

创新的概念

傅家骥

“技术创新就是指科技成果变成商品，并在市场上销售实现其经济价值，进而获得经济效益的过程和行为。”

二、标准化作用的再认识

- 标准在创新的不同阶段发挥作用

技术创新初期

- 标准为技术创新奠定基础；通过固化和锁定技术，可弥补创新初期较高的不确定性和风险性

技术创新中期（产业化阶段）

- 为技术创新成果的产业化搭建了桥梁

技术创新后期

- 可能会阻碍创新

二、标准化作用的再认识

- 标准与专利的结合

背景

知识产业的崛起推动了专利密集度和复杂性的增强

包含专利的技术构成了标准不可替代的技术方案

二、标准化作用的再认识

- 国际、区域、国家标准化组织

1. 标准中可以纳入专利，但应尽量避免
2. 标准中纳入的专利，必须是实施标准不可避免会使用的技术
3. 标准化组织必须获得专利持有者做出的许可声明后，才能将专利纳入标准
4. 标准化组织不介入具体的专利有效性的甄别和专利许可事务

二、标准化作用的再认识

- 论坛、联盟、团体组织

结合的原因

获得技术垄断权 → 分享产业链各个环节的市场利益 → 实现商业利益的最大化

专利池许可

- 内部合作
- 一致对外

二、标准化作用的再认识

启示

一项专利通常只能涉及一个产品，而一项标准，往往会影响一个行业、一个国家，甚至整个世界。

二、标准化作用的再认识

（一）标准与技术创新

（二）标准与产业发展

（三）标准与社会管理

（四）标准化的本质

二、标准化作用的再认识

标准先行

在传统大规模工业化生产中，是先有产品后有标准。而今天，在战略性新兴产业是**“产品未动，标准先行”**。

标准：

从某种意义上说，得标准者得天下

例如

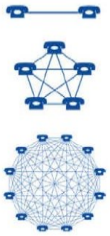
先有IP协议。

高清晰度彩色电视、第三代、第四代移动通信

二、标准化作用的再认识

网络经济学　**基本论点：**

- 网络的外部性产生正反馈(Matthew)效应，“强者恒强，弱者恒弱”，即一定条件下优势或弱势一旦出现→加剧而自我强化→出现滚动的累计效应→甚至导致“赢家通吃，输家出局”的局面。
- 锁定效应(Lock-in effect),系统转换的成本极高/**创新大批习惯用户**。



二、标准化作用的再认识

网络效应”的作用

自用价值

当只有一个消费者时，产品自身所能够产生的价值；

价值随产品用户的增多而增加

网络价值

例如：电话

更多人加入，就意味能够获得更多的交流机会。使用某一网络的人越多，对每个人的价值就越大。因此人们都希望加入人数多的网络。

所以标准先行，就是通过首先确立技术方案和路径，形成产业的“网络效应”,避免市场的无序竞争，锁定消费群体。

二、标准化作用的再认识

技术标准通过锁定技术路径，形成依赖，还向我们展示了另一种情形：获胜者不但占领了绝大部分市场，而且还在相当长的一段时间内保持它，即使面对更为先进的技术，原有技术仍然能够取得竞争的胜利。

例如：微软 Microsoft

其Windows系统占有了90%以上的市场份额，面对其它操作系统的挑战，仍能把市场牢牢地控制在手中。

这说明，一旦一种技术标准占领了市场，就会产生相对持久的控制力，提高企业和产业的可持续发展能力。

二、标准化作用的再认识

技术标准不仅**增加了**发达国家在全球市场上的竞争优势，而且**诱导了**技术后进国家在技术路径上的跟踪模仿和过度依赖，**抑制了**这些国家创新能力的提高，使发展中国家经济发展越来越呈现出**依附性**的特征。

二、标准化作用的再认识

国际标准研制与产业化同步

由中国主导制定了《OLED光学和光电参数测试方法》国际标准，将我国优势技术**“积分球外测试方法”**技术纳入国际标准，该标准已于2009年5月由IEC正式发布

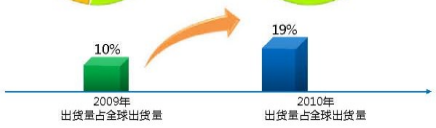
产业化与国际标准研制同步，2008年建成了国内**第一条OLED生产线**，实现了批量生产

二、标准化作用的再认识

国际竞争力提升

2009年全球OLED厂家出货量排名

2010年全球OLED厂家出货量排名



二、标准化作用的再认识

启示

标准化的作用内涵已经从规范产业、行业发展演进到引领和带动产业、行业发展。

二、标准化作用的再认识

（一）标准与技术创新　（三）标准与社会管理　（三）标准与社会管理　（四）标准化的本质

二、标准化作用的再认识

- 社会管理标准化已成为国际标准化组织重点关注的领域

2007年至2009年，ISO新组建了18个技术委员会，其中有7个技术委员会涉及社会管理。

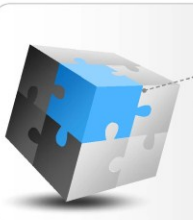
序号	新建的TC	建立时间
1	TC 235评级服务项目委员会	2007年
2	TC 242能源管理项目委员会	2008年
3	TC 240产品召回项目委员会	2008年
4	TC 243消费者产品安全项目委员会	2008年
5	TC 246反盗版工具项目委员会	2008年
6	TC 241道路交通安全管理系统项目委员会	2008年
7	TC 247欺诈对策和控制技术委员会	2009年

二、标准化作用的再认识

- 社会管理标准化已成为国际标准化组织重点关注的领域
- 《国家标准体系建设规划》“五位一体”
- 经济、社会、生态环境、文化和政府管理

二、标准化作用的再认识

启示



标准化工作逐渐从产品技术标准领域拓展到社会、文化和政府管理领域，标准是提高其管理科学化水平，为广大人民群众提供高质量的、有效的管理和服务的技术支撑。

二、标准化作用的再认识

（一）标准与技术创新　（三）标准与社会管理　（三）标准与社会管理　（四）标准化的本质

二、标准化作用的再认识

标准化 standardization ≫ 活动

为了在既定范围内获得最佳秩序，促进共同效益，对现实问题或潜在问题确立共同使用和重复使用的条款以及编制、发布和应用文件的活动

▸注：标准化的主要效益在于为了产品、过程和服务的预期目的改进它们的适用性，促进贸易、交流以及技术合作

目的　范围　对象　内容　产出　效益

二、标准化作用的再认识

标准化 standardization ≫ 文件

通过标准化活动，按照规定的程序经协商一致制定，为各种活动或其结果提供规则、指南或特性，供共同使用和重复使用的文件

▸注：科学、技术和经验的综合成果是标准形成的基础。

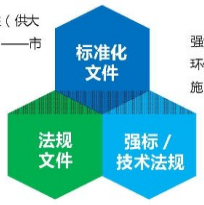
形成　功能　特点　基础　形式

二、标准化作用的再认识

制度体系/规则体系

技术规则、自愿性（供大家“自愿”使用）——市场规律

社会规则、具有普遍约束力（“强制”别人必须执行）——政府 / 权力机关



强制性（“安全、健康、环保”等方面强制实施）——政府

▸旨在保障健康和安全、保护环境，为活动或其结果提供规程或规范，由政府主导制定的强制实施的标准

二、标准化作用的再认识

制度/规则体系

➢ 内部使用的文件 / 技术文件：指令性（供内部使用），不是强制性

◆ 政府自身的社会管理和公共服务的标准化文件
- 政府部门的身份证号码标准

◆ 企业的技术文件
- 产品规范、工艺规程等

二、标准化作用的再认识

制度/规则体系

标准和技术文件

- 企业技术文件：为具体的产品 / 服务提出解决方案，引用标准，适用具体企业
- 标准：对多种类、具有相似功能的产品 / 服务，规定特性指标 / 要求，适用一定范围

同一类型不同层级的文件

- 法规层级——法律、行政法规、条例、规章
- 标准层次——标准、技术规范TS、可公开提供规范 PAS、工艺规程、技术协议等等

介绍内容
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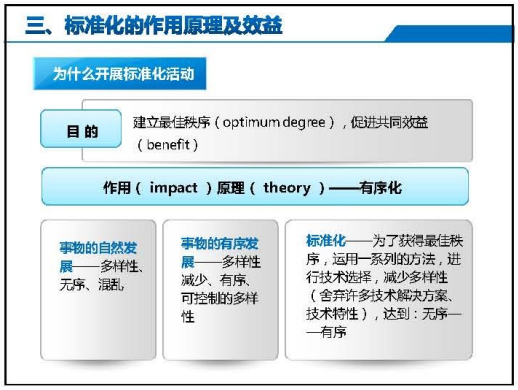
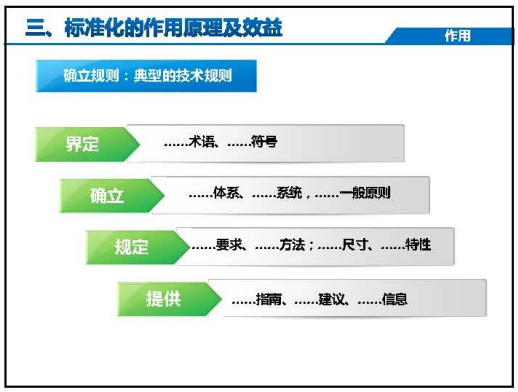
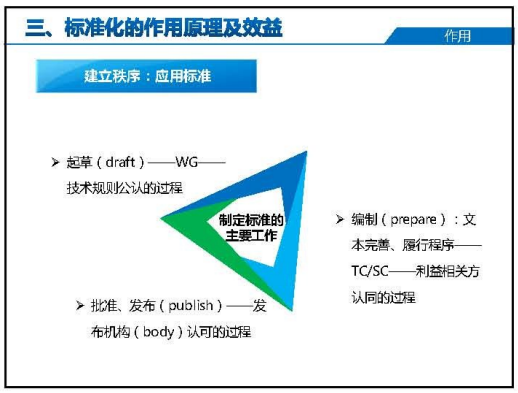
一、标准化的产生与发展
二、标准化作用的再思考
三、标准化作用原理与效益


三、标准化的作用原理及效益
为什么开展标准化活动
目 的
建立最佳秩序（optimum degree），促进共同效益（benefit）
作用（impact）原理（theory）——有序化
事物的自然发展——多样性、无序、混乱
事物的有序发展——多样性减少、有序、可控制的多样性
标准化——为了获得最佳秩序，运用一系列的方法，进行技术选择，减少多样性（舍弃许多技术解决方案、技术特性），达到：无序——有序

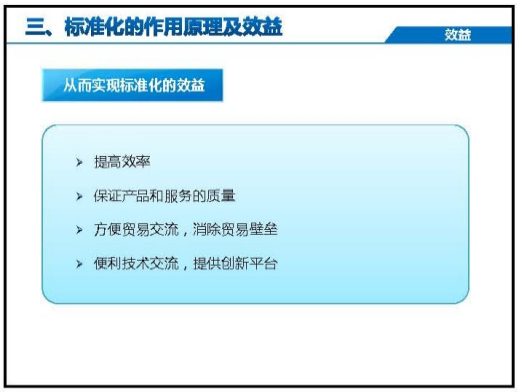

三、标准化的作用原理及效益
作用
确立规则：提供公认的技术规则
针对人类的活动，提供规则或指南；针对活动的结果，给出规则或特性
为了保证可用性等目的，并给技术发展留有自由度，为“活动的结果”建立规则，遵循“性能特性原则”和“可证实性原则”，形成规范标准
为了“保障健康和安全，保护环境”，或者为了“指导生产者的操作过程”，为“活动的过程”建立规则，遵循“过程可操作原则”，形成规程标准
为了提供整体的指导，确立“体系”“系统”“原则”，提供“方向建议”，形成分类标准、指南标准
为了相互理解，界定“术语”“符号”，规定“方法”，形成术语标准、符号标准、方法标准


三、标准化的作用原理及效益
作用
确立规则：典型的技术规则
界定
……术语、……符号
确立
……体系、……系统，……一般原则
规定
……要求、……方法；……尺寸、……特性
提供
……指南、……建议、……信息


三、标准化的作用原理及效益
作用
建立秩序：应用标准
如何保证标准被自愿应用？
技术规则适用性好
形成的标准要被各利益相关方认同
通过标准制定程序
目标：实现技术规则公认、利益相关方认同、制定机构认可
原则：公开、透明、协商一致，达到“公正”


三、标准化的作用原理及效益
作用
建立秩序：应用标准
起草（draft）——WG——技术规则公认的过程
制定标准的主要工作
编制（prepare）：文本完善、履行程序——TC/SC——利益相关方认同的过程
批准、发布（publish）——发布机构（body）认可的过程


三、标准化的作用原理及效益
效益
通过改进产品、过程和服务的适用性，促进贸易、交流和技术合作
如何改进适用性？
通过好的制度设计，设立各方有效参与的组织，确立利益相关方认同的制定程序，形成适用性的技术规则，达到自愿性的广泛应用，建立了技术秩序：
减少了多样性，保证了可用性，增强了互换性、兼容性、互操作性，便于产品防护
保障了人类的健康和安全，保护了环境，促进了资源的合理利用
保证了法规/技术法规的有效实施
增进了相互理解等等

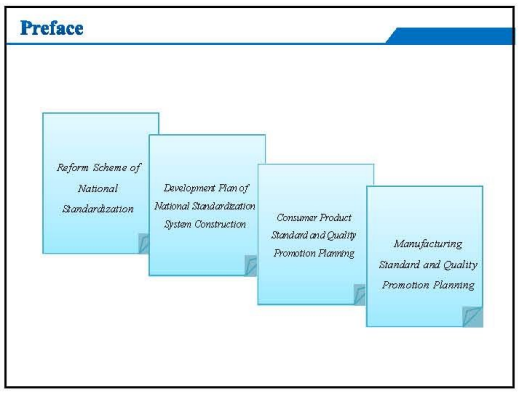

三、标准化的作用原理及效益
效益
从而实现标准化的效益
提高效率
保证产品和服务的质量
方便贸易交流，消除贸易壁垒
便利技术交流，提供创新平台

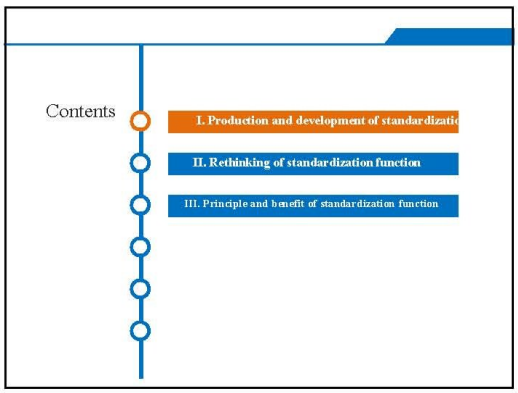

谢 谢！
中国标准化研究院 汤万金
二〇一六年十一月十七日
•Tangwj@cnis.gov.cn


Re-recognition of Standardization Effect
China National Institute of Standardization
Tang Wanjin
November 17, 2016
•Tangwj@cnis.gov.cn


Preface
Standard results from human civilization and progress. Standardization plays an increasingly prominent role in facilitating the economic and trade contact, supporting the industry development, promoting the scientific and technological progress and regulating the social governance.
China would proactively implement the standardization strategy, and help the innovation development, coordination development, green development, open development and shared development with standard.


Preface
Confronting the difficulty and challenge, the economy shall be smoothly run, not only keep the total demand strength, but also accelerate the structural reform of supply side, and focus on improving the supply quality. So it's necessary to put the standardization at the more prominent position, comprehensively improve and promote the industry upgrading with standard, and form new competitive advantage to promote the high-middle speed growth of economy which steps into the high-middle end level.


Preface
Reform Scheme of National Standardization
Development Plan of National Standardization System Construction
Consumer Product Standard and Quality Promotion Planning
Manufacturing Standard and Quality Promotion Planning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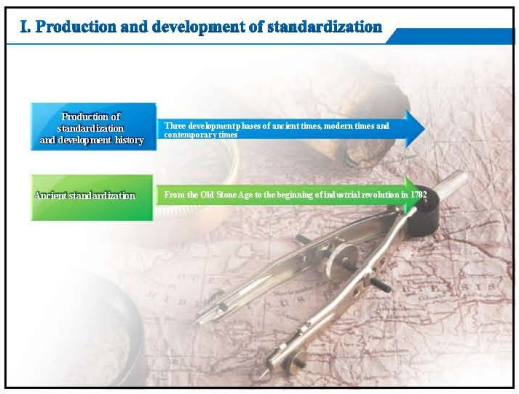
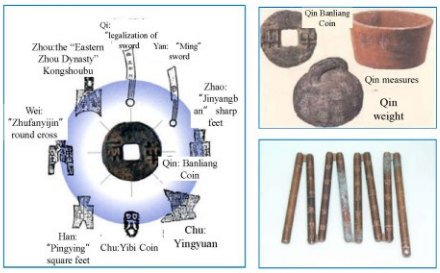
II. Rethinking of standardization function
III. Principle and benefit of standardization function


I. Production and development of standardization
Production of standardization and development history
Three development phases of ancient times, modern times and contemporary times
Ancient standardization
From the Old Stone Age to the beginning of industrial revolution in 1782

I. Production and development of standardization

- First Emperor of Qin unified currency and weights and measures



I. Production and development of standardization

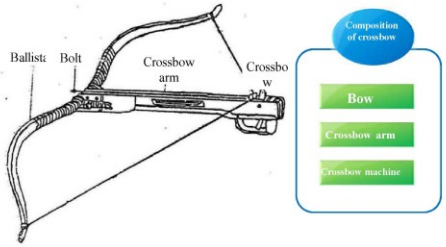
- Terra-Cotta Warriors

I. Production and development of standardization

- Terra-Cotta Warriors

I. Production and development of standardization

- Terra-Cotta Warriors



I. Production and development of standardization

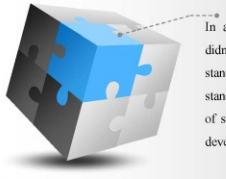
- Terra-Cotta Warriors

Archaeologists verify that the production management system of armament weaponry in Qin State is divided into four grades on the basis of record of "manufactures' name is inscribed on utensils" in *Lvshi Chunqiu*:

Xiangbang	Prime Minister, equal to State Prime Minister nowadays. Most of the weapons unearthed at present are inscribed the name of Lv Buwei (Prime Minister in Qin dynasty)
Gongshi	Factory director in plant
Cheng	Production director in plant
Overman	Worker actually producing weapon

I. Production and development of standardization

Enlightenment



In ancient China, although the standard didn't exist in text form, but it's fixed in the standardization object. The enlightenment of standardization thought and the application of standardization method greatly drive the development of China's ancient civilization.

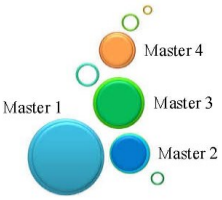
I. Production and development of standardization

- The modern standardization starts from the industrial revolution to the middle of the 20th century
- In 1782, Watt invented the steamer, which marks the beginning of the industrial revolution

Industrial revolution is the change of production modes from the backward production mode of original manual workshop to the mechanization and scale production methods

I. Production and development of standardization

The production of manual workshop refers that the master leads apprentice from the initial design to the final product; the master takes complete responsibility. The products produced by two masters are different.



I. Production and development of standardization

The development of productivity results in the internal labor division of enterprise, and greatly promotes the internal standardization of enterprise .

Main purpose for internal standardization of enterprise is to improve the production efficiency, and its basic principles are to utilize the interchangeability of standard component.

I. Production and development of standardization

After being sent to the slaughter house, the cow would be stunned by electric shock, hung up, then disemboweled by electric saw, finally, be parted. These processes are respectively completed by different persons.

Ford discovery: The streamline operations have high work efficiency, which could be applied in the automobile making.

"Workers and peasants are men really needing automobile, so I propose to produce on basis of standardization on a large scale, and sell the cheap and practical automobile to these persons, which is the long-term strategy of our company!"

I. Production and development of standardization

The first automobile assembly line in the world was born in Ford's plant. The assembly line has standard to each procedure of production and each action of worker.

1 automobile is produced in one minute

1 automobile is produced in ten seconds

1913 — 1920 — 1925

I. Production and development of standardization

Ford

308,162 vehicles were produced in 1914

Exceed the production sum of other 299 automobile factories in America

In 1921, the yield of T-type vehicle had exceeded 56.6% total yield of world automobile. Standardization assembly line created by Ford establishes the model for future automobile industry development.

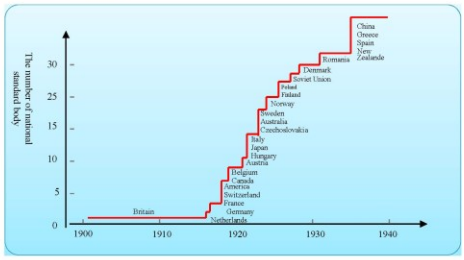
I. Production and development of standardization

When an enterprise couldn't independently complete the production of one product, the professional division occurs among enterprises, meanwhile, the universality and interchangeability are also confronted.

The demand to the folk standardization organization occurs.

Since the development of production and the scope for cooperation expands, standards are not only required to unify in industry scope, but also to the cross-industry and global scope, so the national standard generates. Meanwhile, the national standardization organization also occurs.

I. Production and development of standardization



Speed for establishment of the national standard body from 1901 to 1932

I. Production and development of standardization

Enlightenment

The promotion role of standardization to industrial revolution is just as the statement of Frederick W. Taylor (1856-1915), the founder of classical management in *Principle of Scientific Management*:

"Only the insistence of standardization method and cooperation could insure the faster work process. The insistence of standardization adoption and cooperation is the only responsibility endowed to management."

I. Production and development of standardization

Contemporary standardization starts from the middle of the 20st century to present times.

Vigorous development of international trade generates the contemporary standardization.

Standardization embodies the distinct characteristics of internationalization and systematicness.

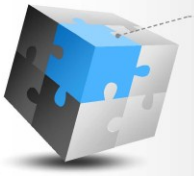
I. Production and development of standardization

- The formation and development of standard category go through the following processes:

Enterprise Standards → Association standards → National standards → International standards

I. Production and development of standardization

Enlightenment



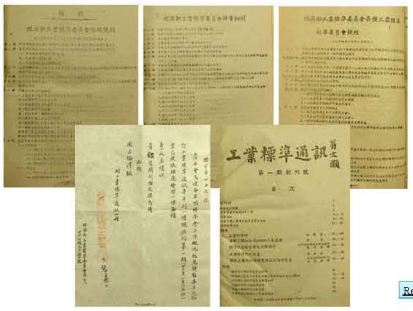
Standard becomes the "common language" for international trade. The function exerted by standard is just as the ISO tenet: the formulation of international standard is in order to "facilitate the exchange and service of international logistics, and expand the cooperation of knowledge, science, technology and economy fields".

I. Production and development of standardization

Standardization memorabilia

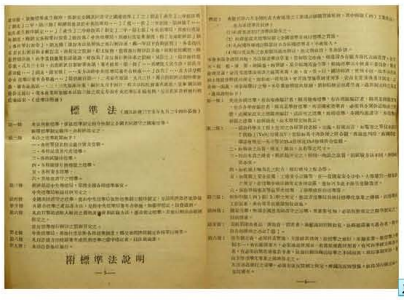
- 1931 — Republic of China Government Industry Standards Committee was established
- 1946 — Republic of China Government published *Standard Law*
- 1946 — The representatives of Republic of China participated in the ISO founding conference convened in London from October 14 to 26
- 1947 — Weights and Measures Bureau and Standardization Administration Committee of the Republic of China were merged, and the Central Bureau of Standards was established
- 1949 — Administration of the Central Technology of the Central People's Government of the People's Republic of China establishes the subordinate standard specification office
- 1955 — The State Technological Commission of the People's Republic of China was established, and the Bureau of Standards was founded

I. Production and development of standardization



Return

I. Production and development of standardization



Return

I. Production and development of standardization

Return

I. Production and development of standardization

Standardization memorabilia

- 1958 — Scientific Planning Committee and Technological Committee were merged into State Scientific and Technological Commission, and the Bureau of Standards was founded
- 1972 — National Standard Measuring Bureau was established
- 1978 — National Bureau of Standards was established
- 1988 — The Fifth Meeting of the Seventh Session National People's Congress Standing Committee passes the *Standardization Law of the People's Republic of China*
- 2001 — The Standardization Administration of the People's Republic of China was established with approval of the State Council
- 2008 — China officially became a permanent member of ISO

Contents

II. Recognition of standardization function

(I) Standard and technology innovation

(II) Standard and industry development

(III) Standard and social management

(IV) Essence of standardization

II. Recognition of standardization function

The concept of innovation

The "Innovation" concept was proposed by Austrian economics J.A. A. Schumpeter, American Austrian, in the German version *The Theory of Economic Development* for the first time in 1912. So he became the founder of innovation theory. In the opinion of Schumpeter, "innovation" not only refers to the invention and innovation of science and technology, but also refers to a kind of new production ability formed after the invented science and technology was introduced into the enterprises.

II. Recognition of standardization function

The concept of innovation

Schumpeter

"Invention is first, innovation is second. The invention refers to the discovery of new tools or new methods, while innovation refers to the implementation of new tools or new methods."

"As long as the invention isn't actually applied, it doesn't play a part in the economy."

II. Recognition of standardization function

The concept of innovation

American economist E.Mansfield thought that "Innovation is the first application of invention."

II. Recognition of standardization function

The concept of innovation

Fu Jiaji

"The technological innovation refers to the process and behavior that the scientific and technological achievements turn into commodity, and achieve the economic value by sale in market, thus gain the economic benefit."

II. Recognition of standardization function

- Standard exerts function in different stage of innovation

Initial period of technological innovation

- Standard lays the foundation for technological innovation. The higher uncertainty and risk at the beginning of innovation could be remedied by the solidifying and locking technique

Medium term of technological innovation (industrialization stage)

- Establish the bridge for the industrialization of technological innovation product

Later period of technological innovation

- May impede innovation

II. Recognition of standardization function

- Combination of standard and patent

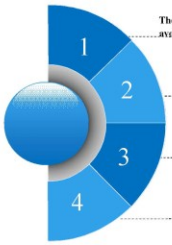
Background

The rising of knowledge industry promotes the reinforcement of patent intensity and complexity

The technology with patents constitute the irreplaceable technology proposal of standard

II. Recognition of standardization function

- International, regional and national standardization organizations



The patent could be included in the standard, but shall be avoided as far as possible

The patent absorption in standard shall be the inevitable technology used in the standard implementation

Standardization organization shall include the patent in the standard after gaining the license statement made by patent holder

Standardization organization doesn't intervene in the specific screening of patent effectiveness and the patent license matters

II. Recognition of standardization function

- Forum, alliance, incorporation

Reason for combination

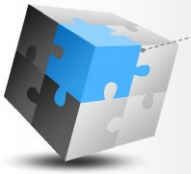
Gain the technology monopoly right → Share the market interests in each link of industry chain → Achieve the maximization of commercial interests

Patent pool permission

- Internal cooperation
- Unify against foreign

II. Recognition of standardization function

Enlightenment



One patent could only involve one product usually, while one standard could often influence one industry, one country, even the whole world.

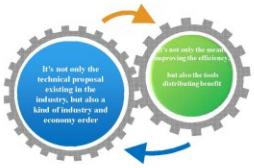
II. Recognition of standardization function

II. Recognition of standardization function

Standard

Product is the first and the standard is the second in the traditional large-scale industrialization production. While, the "product is the second and the standard is the first" in the strategic emerging industry nowadays.

Standard:



In a sense, The Man Who Gain Standard Will Gain the World

For example

Firstly have the IP agreement.

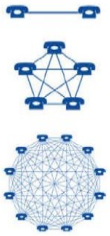
Color television with high definition, the third generation and the fourth generation of mobile communication

II. Recognition of standardization function

Network economics

Basic contention:

- The network externality generates the positive feedback (Matthew) effect - "the stronger gets stronger and the weaker gets weaker", namely, once the advantage or weakness occurs under certain condition →aggravate with self-reinforcement →the rolling cumulative effect occurs →even cause the situation of "winner monopolizes, the loser eliminates".
- As for the lock-in effect, the transfer cost of system is very high/create lots of regular users.



II. Recognition of standardization function

Function of "network effect"

Self-value

The value that the product could generate only with one consumer;

The value increases as the product customers increase

Network value

For example: Telephone

That more people joining in the net means more exchange opportunities could be gained. The network that more persons use has greater value to each person. Therefore, people hope to join in the network with more persons.

So the standard first refers that the "network effect" of industry is formed by firstly confirming the technical scheme and path to avoid the disordered competition of market and lock the consumer group.

II. Recognition of standardization function

Technical standard forms a reliance by locking technical path, and shows us another situation: The winners not only occupy most markets, but keep the dominant position for quite a long time. The original technology can win even in front with more advanced technology.

For example: Microsoft

The Windows system holds over 90% market shares and keeps its dominant position confronted with challenges from other operating systems.

This indicates that once a technical standard occupies the markets, a long-term control will generate to improve the sustainable development capacity of enterprises and industries.

II. Recognition of standardization function

The technical standard enhances the competitive advantages of the developed countries in the global market, and induces the technology-backward countries to intimate and excessively rely on its technical path, further inhibiting the enhancement of innovation ability of these countries and making the developing countries increasingly rely on them in economic development.

II. Recognition of standardization function

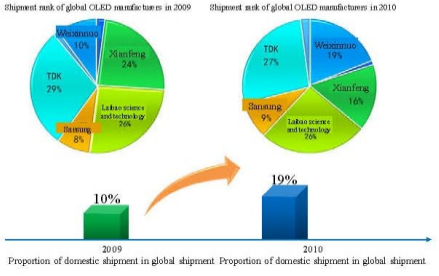
Synchronous development of international standard and

The international standard *OLED Measurement Methods for Optical and Photoelectric Parameters* formulated under the leadership of China includes our advantage technology "Integrating sphere test method" into the international standard. The standard has been formally issued on May 2009 by IEC

Industrialization keeps up with the development of international standards. In 2008, the first OLED production line is completed in China, realizing batch production

II. Recognition of standardization function

Enhancement of international competitiveness



II. Recognition of standardization function

Enlightenment

The effect of standardization has evolved from standardizing industrial development to leading and driving industrial development.

II. Recognition of standardization function

II. Recognition of standardization function

- The standardization of social management has become the key field concerned by ISO

From 2007 to 2009, ISO established 18 technical committees, and 7 of them are related to social management.

S/N	Newly established TC	Establishment time
1	TC 235 Rating Services Project Committee	2007
2	TC 242 Energy Management Project Committee	2008
3	TC 240 Product Recall Project Committee	2008
4	TC 243 Consumer Products Safety Project Committee	2008
5	TC 246 Anti-piracy Tool Project Committee	2008
6	TC 241 Road Traffic Safety Management System Project Committee	2008
7	TC 247 Fraud Countermeasures and Control Technical Committee	2009

II. Recognition of standardization function

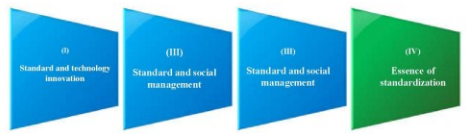
- The standardization of social management has become the key field concerned by ISO
- *National Standard System Construction Planning* "five in one"
- Economic, social, ecological environment, cultural and government management

II. Recognition of standardization function

Enlightenment

Standardization gradually expands from product technology to social, cultural and government management. Standard is a technical support to improve scientific management and provide quality and efficient management and services for the public.

II. Recognition of standardization function



II. Recognition of standardization function

Standardization ⟫ Activities

To obtain an optimum degree within the given range, facilitate common benefit, establish terms of common use and repeated use and their preparation, issuance and application documents

▸Note: The main effect of standardization is that it can improve the adaptability of products, processes and services to realize their intended purposes, and facilitate transactions, communication and technical cooperation

Purpose | Scope | Object | Content | Output | Benefit

II. Recognition of standardization function

Standardization ⟫ Document

Formulate as per specified procedures under consensus through standardization activities; provide rules, guidelines or characteristics for various activities or its results as well as the documents which has common and repeated use

▸Note: Comprehensive achievements of science, technology and experience are the basis of a standard.

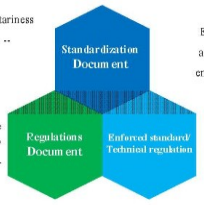
Formation | Function | Features | Base | Form

II. Recognition of standardization function

Policy system/rule system

Technical rules, voluntariness (for the voluntary use) -- market discipline

Social rules binding to the general public (*enforce* others to implement) -- government/authority



Enforceability (enforced in aspects of"safety, health and environmental protection") -- government

▸Aim to ensure health and safety and protect the environment; to provide procedures or specifications for activities or its results; the standards of enforced implementation dominated and formulated by the government

II. Recognition of standardization function

Policy/rule system

- Document/technical document for internal use Mandatory (for internal use), but not enforced
  - ◆ Social management and public service standardization documents of the government
    - ID card number standard of government department
  - ◆ Technical document of enterprise
    - Product standardization, technological procedure, etc.

II. Recognition of standardization function

Policy/rule system

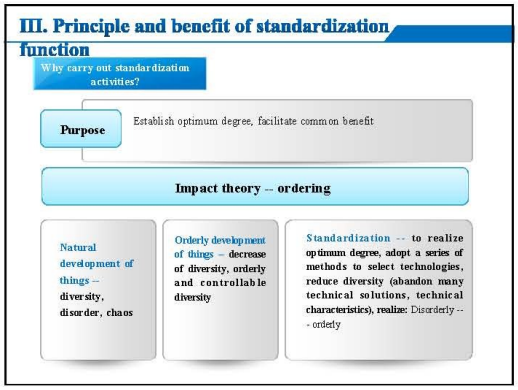
Standard and technical docum en

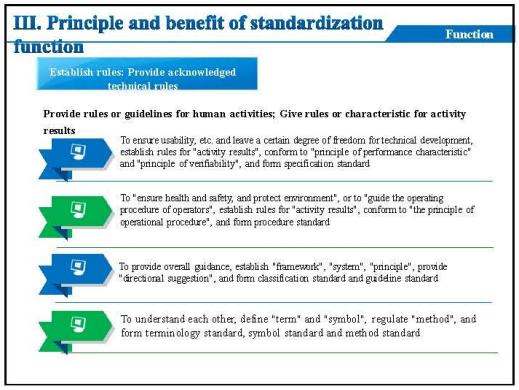
- Technical documents of enterprises: To offer solutions for specific products&services, reference standard, applicable to specific enterprises
- Standard: Stipulate index of characteristics/requirements for variation of products with similar function, applicable to a certain range

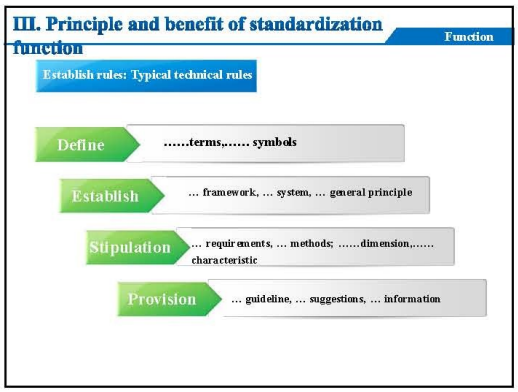
Document with the same type but at different level

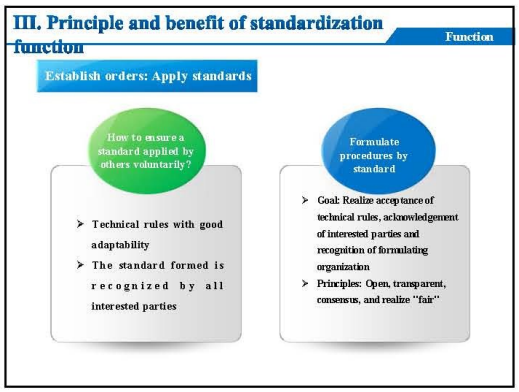
- Regulatory level -- laws, administrative regulations, rules and regulations
- Standard level -- standard, technical specification TS, publicly available specification PAS, process specification, technical agreement, etc.

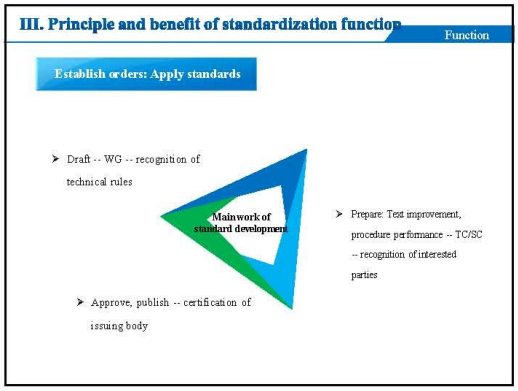
Contents

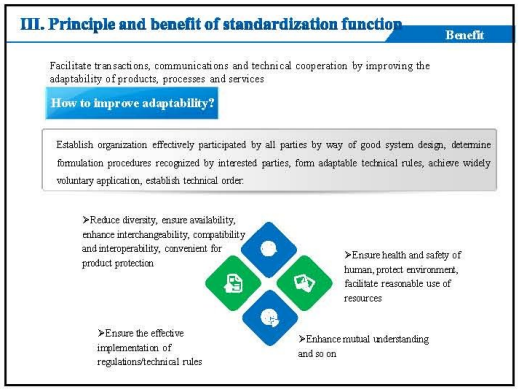

III. Principle and benefit of standardization function
Why carry out standardization activities?
Purpose
Establish optimum degree, facilitate common benefit
Impact theory -- ordering
Natural development of things -- diversity, disorder, chaos
Orderly development of things -- decrease of diversity, orderly and controllable diversity
Standardization -- to realize optimum degree, adopt a series of methods to select technologies, reduce diversity (abandon many technical solutions, technical characteristics), realize: Disorderly -- orderly

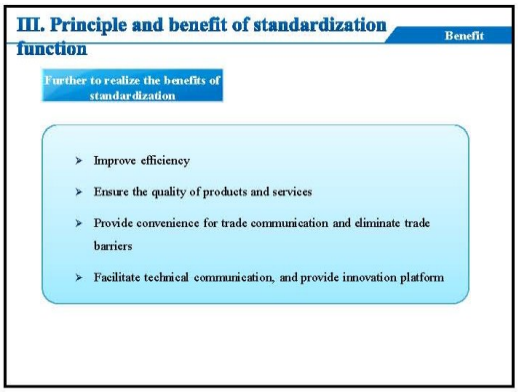

III. Principle and benefit of standardization function
Function
Establish rules: Provide acknowledged technical rules
Provide rules or guidelines for human activities; Give rules or characteristic for activity results
To ensure usability, etc. and leave a certain degree of freedom for technical development, establish rules for "activity results", conform to "principle of performance characteristic" and "principle of verifiability", and form specification standard
To "ensure health and safety, and protect environment", or to "guide the operating procedure of operators", establish rules for "activity results", conform to "the principle of operational procedure", and form procedure standard
To provide overall guidance, establish "framework", "system", "principle", provide "directional suggestion", and form classification standard and guideline standard
To understand each other, define "term" and "symbol", regulate "method", and form terminology standard, symbol standard and method standard


III. Principle and benefit of standardization function
Function
Establish rules: Typical technical rules
Define
……terms,…… symbols
Establish
… framework, … system, … general principle
Stipulation
… requirements, … methods; ……dimension,…… characteristic
Provision
… guideline, … suggestions, … information


III. Principle and benefit of standardization function
Function
Establish orders: Apply standards
How to ensure a standard applied by others voluntarily?
Technical rules with good adaptability
The standard formed is recognized by all interested parties
Formulate procedures by standard
Goal: Realize acceptance of technical rules, acknowledgement of interested parties and recognition of formulating organization
Principles: Open, transparent, consensus, and realize "fair"


III. Principle and benefit of standardization function
Function
Establish orders: Apply standards
Draft -- WG -- recognition of technical rules
Mainwork of standard development
Prepare: Test improvement, procedure performance -- TC/SC -- recognition of interested parties
Approve, publish -- certification of issuing body


III. Principle and benefit of standardization function
Benefit
Facilitate transactions, communications and technical cooperation by improving the adaptability of products, processes and services
How to improve adaptability?
Establish organization effectively participated by all parties by way of good system design, determine formulation procedures recognized by interested parties, form adaptable technical rules, achieve widely voluntary application, establish technical order.
Reduce diversity, ensure availability, enhance interchangesibility, compatibility and interoperability, convenient for product protection
Ensure health and safety of human, protect environment, facilitate reasonable use of resources
Ensure the effective implementation of regulations/technical rules
Enhance mutual understanding and so on


III. Principle and benefit of standardization function
Benefit
Further to realize the benefits of standardization
Improve efficiency
Ensure the quality of products and services
Provide convenience for trade communication and eliminate trade barriers
Facilitate technical communication, and provide innovation platform


Thank you!
China National Institute of Standardization Tang Wanjin
November 17, 2016
Tangwj@cnis.gov.cn

约翰·金尼尔

约翰·金尼尔，IBM 高级工程师，专门从事过程和系统技术，以及 ANSI / ESD S20.20 工厂认证。获得布法罗大学学士学位和锡拉丘兹大学硕士学位，因对国家标准和国际标准的突出技术贡献而享誉全球。

金尼尔先生曾担任 IBM 跨部门静电防护技术联络委员会主席，是 IBM 企业静电防护大纲制定和实施委员会的重要成员，1989 年以来，一直担任 IBM 波基普西（美国纽约州）工厂的现场静电防护协调员。金尼尔先生致力于大型商业服务器的 EMC、安全、环境、运输和挥发性有机化合物排放标准的符合性测试。他同时也是需要 FCC（美国联邦通信委员会认证）、CE 标志（欧盟安全认证）、VCCI（日本电磁兼容认证）等认证要求的首席工程师，负责主要大型商业服务器系统的 EMC 辐射测试和抗扰度标准测试。

自 1990 年成为 ESD 协会成员以来，金尼尔先生曾在几个标准发展委员会任职，并担任协会管理职位。作为国际电工委员会（IEC）美国代表，金尼尔先生被委任为美国全国委员会/ IEC 101 技术委员会技术顾问，他积极促进国际静电防护标准发展，支持 ANSI / ESD S20.20 标准国际化。作为 ESDA（美国静电放电协会）的工厂认证（ANSI / ESD S20.20）发展计划主席，金尼尔先生在该计划的开发和推广中发挥了重要作用，尤其在开发阶段，推动了主任评审员培训、国际注册认证和现场审核的协调发展。从副总裁、高级副总裁到总裁，金尼尔先生先后担任了 ESD 协会的每个管理职位。他是 EOS / ESD 研讨会技术委员会原主席和 2004 年 EOS / ESD 研讨会大会主席。金尼尔先生对 ESD 协会做出了突出贡献，于 2006 年 9 月获得协会颁发的杰出贡献奖。

John Kinnear

John Kinnear is an IBM Senior Engineer specializing in process & system technology, and facility certification in accordance with ANSI/ESD S20.20. He has a BS degree from University of Buffalo and a MS degree from Syracuse University. John is well known globally for his technical contributions to national and international standards He has been the IBM ESD Site Coordinator for the Poughkeepsie site since 1989. He is the past chairman of the IBM Inter-divisional Technical Liaison Committee for ESD Protection and is an important member of his company's committee to develop and implement the ESD Corporate program for IBM. John has coordinated the testing of large mainframes for compliance to EMC, Safety, Environmental, Shipping and Volatile Organic Emission standards. He has also been the lead engineer on testing large mainframe systems to EMC emissions and immunity standards for FCC, CE Mark, VCCI and other national requirements. As a member of the ESD Association since 1990, John has served in several Standards Development Committees as well as association management positions. John is the appointed Technical Adviser to the United States National Committee/IEC Technical Committee 101, where he represents the United States to the International Electrotechnical Commission (IEC). In this position he assisted in the evolution of international ESD standards and supports international adoption of ANSI/ESD S20.20. As Chair of the ESDA's Facility Certification (ANSI/ESD S20.20) development program, John played major roles in the program's development and industry launch. In particular, John coordinated the initial development of Lead Assessor training, ISO Registrar Certification, and witness audits. John has served in every ESD Association officer's position, including Vice President, Senior Vice President and President. He is the past Chairman of the EOS/ESD Symposium Technical Program Committee and past General Chairman of the 2004 EOS/ESD Symposium. For his contributions to the ESD Association, John was presented with the Outstanding Contribution Award in September, 2006, from the ESD Association.

静电放电控制过程评估

John Kinnear
IBM

评估静电放电控制过程的目的

- 描述处理静电放电敏感物件控制过程的特征。
- 目标：在已经采用了静电控制过程情况下，确定是否正在发生具有潜在危害性的静电放电事件或者是否在人、设备、材料或装置上产生了明显的静电电荷（例如S 20.20）。
- 评估是否能够在静电控制过程中安全操作具有一定耐受电压的装置。
- 在需要提高静电放电防护能力的情况下，提高静电放电控制过程的静电放电防护能力。

哪些情况不符合静电放电控制过程评估?

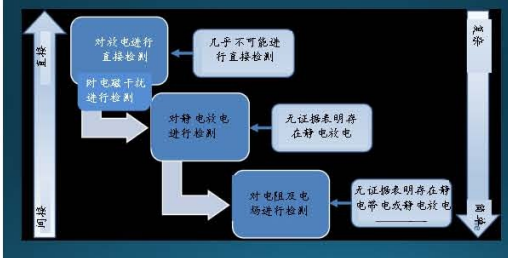
- 静电放电控制过程评估不在于审核静电放电控制过程是否与公司的静电控制计划相符。
- 静电放电控制过程评估不能采取简单的方法进行评估，必须由掌握静电检测知识和经验的高级工程师进行控制过程评估。

注意：上述检测值
- 只在检测时有效，此后该检测值或许发生变化，或许不发生变化。
- 只在如下条件下有效（环境、过程、操作人员）。

静电放电协会 流程评估工作组

- 创建于2010年。
- 第一份出版物：静电放电TR 17.0-01-15技术报告"静电过压/静电放电协会用于电子生产线的静电放电控制过程评估方法的技术报告 – 最佳工业实践"
  - 向读者提供控制过程评估方法及测试方法的"最佳实践"的例子。
  - 在任联合主席：
    Reinhold Gaertner - 德国英飞凌公司
    Wolfgang Stadle - 美国英特尔公司

SP 17.1 – 2016: 静电放电控制过程评估 – 检测技术

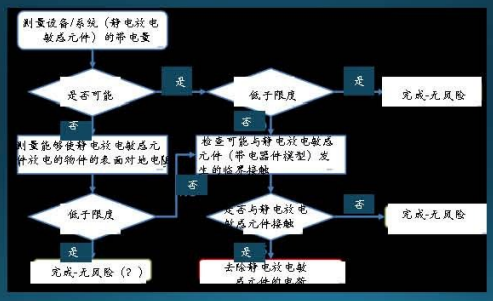


SP 17.1-2016: 静电放电控制过程评估 – 检测技术

	工作人员	导体	绝缘体	设备/印刷电路板
接地	高阻表	电气过载保护技术	高阻表	–
电荷	–	法拉第杯	法拉第杯	法拉第杯
带电电压	CPM/WKI SVM HIDVM	SVM HIDVM FM	SVM HIDVM FM	SVM HIDVM (FM)
静电场	FM	FM	FM	FM
放电电流	电流探测器 伽莱格里尼目标 （带电器件模型的磁头）	电流探测器 伽莱格里尼目标 （带电器件模型的磁头）	–	电流探测器 伽莱格里尼目标 （带电器件模型的磁头）
放电事件	带有示波器的天线 放电事件检测器	带有示波器的天线 放电事件检测器	–	带有示波器的天线 放电事件检测器

SP 17.1-2016: 控制过程评估 – 例子: 工作人员带电/放电风险分析流程图

SP 17.1-2016: 静电放电控制过程评估 – 例子: 设备带电



静电放电控制过程能力示例

致谢:
Stephen Halperin
Ron Gibson

静电放电控制过程能力示例及转换分析示例

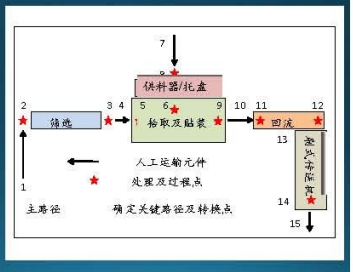
- 确定控制过程的关键路径及转换点
- 进行转换分析的各种检测
- 结果总结

确定关键路径

- 完成产品或总装所需的一系列任务及转换元件（转换点）
  - 从接收开始到装运结束。
  - 关键路径及相关支持活动。
  - 检查全部路径及支持活动。
  - 转换点分为两类:
    能够为设备、组件或产品增加价值或增加转换元件的过程功能。
    从某一任务转换到另一任务。

关键路径的个案研究

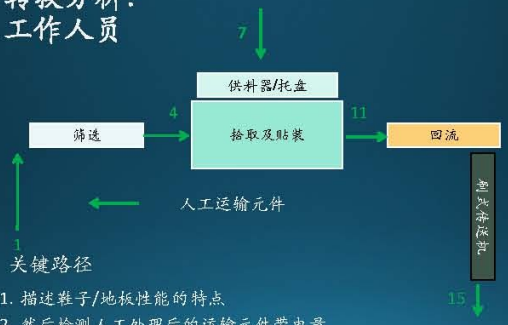
- 过程包括三个关键操作:
1. 筛选电路板
2. 安装部件
3. 回流



分析点的个案研究

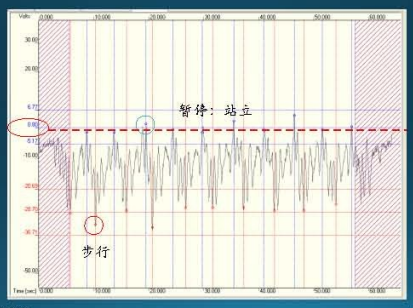
- 工作人员带电
- 印刷电路板筛选器
- 表面贴装技术（SMT）
  - 装填零件
  - 贴装设备
  - 使用设备移动电路板
- 回流

转换分析：工作人员

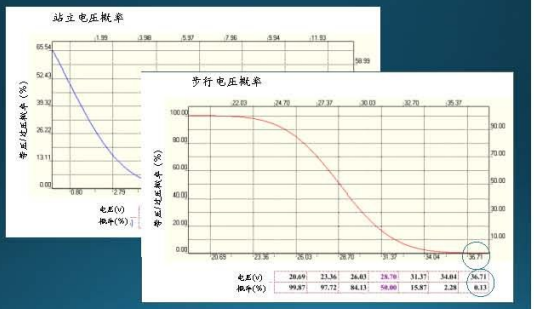


1. 描述鞋子/地板性能的特点
2. 然后检测人工处理后的运输元件带电量

描述鞋子/地板性能的特点 数据及概率分析



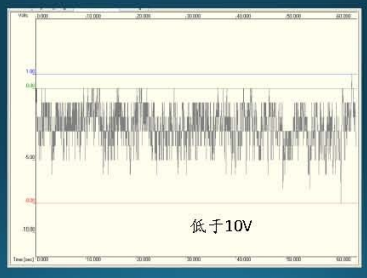
描述鞋子/地板性能的特点 概率分析



工作人员电压：安装筛选器

范围：
+1V

-8V



工作人员电压：从筛选器移至贴装机（SMT）

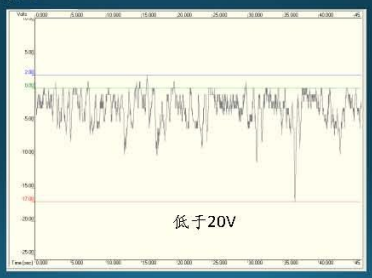
范围：
-1V

-10V

工作人员电压：从由工作人员操作的装料盘到给料器

范围：
+2V

-17V



工作人员带电

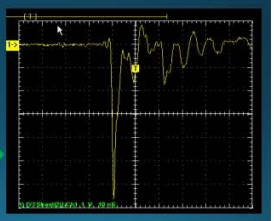
- 总结
  - 工作人员无明显带电。

Transitional Analysis: Screener

筛选器分析

- 将空板放入筛选器中。
  - 使用接触性电压计测量导电线路的电压。
    - 电路板是否带电？
      - 如果带电，放电路径：CT-1发花圈。
      - 确定静电放电危险类型。
- 空板退出筛选器。
  - 再次进行测量。
- 确定是否需要下一步行动。

使用CVM得到
筛选前≤40 V
筛选后-268V 至 -441V



放电类型：CDM

筛选器分析

- 总结：
  - 筛选过程使电路板上的导电元件带电。
  - 如果未去除带电电荷，在可行情况下，可在贴装和处理静电放电敏感元件的过程中放置静电放电源。
    - 注：在筛选器的输出端处安装吊顶离子发生器可将静电电压降低至少于10伏。

表面贴装技术分析

- 在表面贴装的过程中，需要对以下几项进行评估：
  - 表面贴装设备的运输及安装
    （真空供料器、模带及卷轴）
  - 在贴装过程中，设备中是否存在带有电荷的绝缘体（电场引起的带电器件模型）？
  - 电路板贴装设备前，贴装设备是否将电荷传导给零件？

转换分析：给料器

表面贴装技术分析：给料器的集成电路输入

- 工作人员将托盘装入给料器中。
  - 在将托盘装入给料器后，检查零件的电压（CVM）。
    - 未发现有电压。
  - 如果带静电，记录下电压值，并证实放电类型（CT-1及范围）

转换分析：拾取及贴装

表面贴装技术分析：拾取及贴装

- 过程描述
  - 手工安装筛选后的电路板。
  - 传送机将电路板放置在指定的位置。
  - 机器拾取集成电路并贴装在电路板上。
  - 传送机将电路板送至机器出口处。

表面贴装技术分析：拾取及贴装

- 可能存在的静电放电相关问题：
  - 位于贴装处附近的静电发生器。
  - 绝缘的带电的贴装吸嘴。
  - 拾取过程导致的带电零件。
  - 我们已经测量了零件的电量，确定这些零件在被拾取前不带电。

表面贴装技术分析:
拾取及贴装过程中出现的静电场

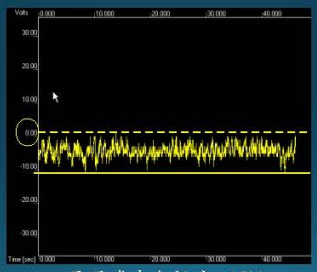
- 在贴装位置附近放置静电场发生器。
  - 使静电场测量及记录设备通过设备的关键路径。
  - 记录可能存在的静电场。

安装运送器并开启记录器
两个影响准确度的关键因素

注意通信处理模块与护栏之间的空间。

确保仪器合理接地

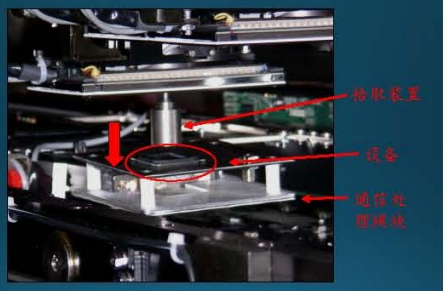
检查所记录的静电场测量值



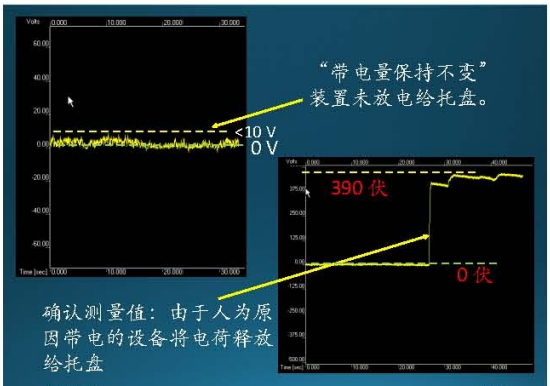
最强感生电场应< 12V

表面贴装技术分析:
在拾取及贴装过程中放电。

- 确保托盘中的零件已经接地。
- 拾取零件并贴装在固定的通信处理模块上。
  - 通信处理模块与设备共同承担设备均带静电。
    - 电荷来自吸嘴与集成电路之间的相互摩擦。
    - 一种可能是将电压保持在50V以下。



用于拾取设备并将设备安装在通信处理模块中的程序化装置



确认测量值：由于人为原因带电的设备将电荷释放给托盘

拾取及贴装

- 表面贴装设备总结
  - 给料器：集成电路及托盘接地且不带电。
  - 关键路径中的静电场：无需考虑
  - 集成电路处理而导致的摩擦带电：无需考虑

转换分析: 回流

回流分析

- 人为将电路板放置在金属传送机上。
  - 在安装前测量表面贴装电路板的电压（来自筛选器的剩余电荷）约为200V。
  - 传送机通过机架连接接地(R_{tg})。
  - 注意：在带电电路板与接地的金属传送机之间是否存在放电?
    - 在回流后输送系统收集电路板（可能发生静电放电事件）。
  - 在回流后输送系统收集电路板。

确定出现静电放电事件 回流时重复放置电路板

所记录的电路板回流后产生的放电

刷式传送机传送电路板

…然后释放电荷到这些电路板上

通过CVM测得电路板的带电电压大于500V。

刷子无静电消散或接地。

回流分析: 总结

- 在装载回流传送机时记录的放电情况。
  - 电路板带电200V–筛选器操作产生的残余静电
- 回流元器件在退出传送机时将超过500伏的静电传给电路板。
  - 可能将电荷释放给操作人员，或可能在进行下一道工序时出现放电。
  - 改变传送系统或在回流后进行电离。

过程分析总结

工序	输入电压	输出电压	是否会超特定值？
待处理	40	268 - 441	否
表面贴装触摸器设备输入	~ 0	< 50	是
使用元件表面贴装技术贴装元器件	216	95 – 200 V[1]	否
测试	高达 200 V[1,2]	> 500 V	否

[1]在筛选电路板的操作过程中产生残余电压。
[2]确认发生静电放电事件。

过程分析总结

- 静电放电控制过程对于超灵敏设备至关重要。
- 静电放电控制过程能够发现所有的静电放电模型。
  - 测量操作人员产生的带电量。
  - 测量零件的带电量。
  - 在任意时刻测量零件与金属发生接触的带电量。

Process Assessment

John Kinnear
IBM

Purpose of ESD Process Assessment

- Characterize a process where ESD sensitive items are handled
- The objective is to identify if potentially damaging ESD events are occurring or if significant electrostatic charges are generated on people, equipment, materials or devices, even though there is a static control process in place (e.g., S20.20)
- Assess whether devices of a given withstand voltage can be handled safely in the process
- Improve ESD capabilities of process if required or desired

What is ESD Process Assessment NOT?

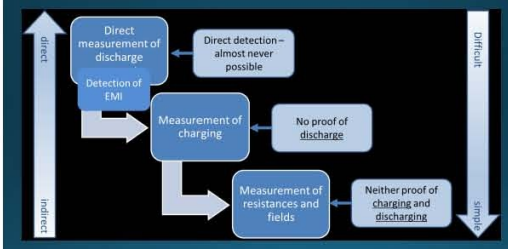
- It is NOT an ESD audit which checks for compliance with an ESD Control Plan of a company
- It is NOT a simple method, process assessment must only be performed by advanced engineers possessing knowledge and experience with electrostatic measurements

Be careful: the measurements
- Are valid only at the time they are made and may or may not change with time
- Are only valid under exactly these conditions (environmental, process, operator, etc.)

ESD Association WG17

- Established in 2010
- 1st publication: Technical Report ESD TR17.0-01-15
  - "EOS/ESD Association Technical Report for ESD Process Assessment Methodologies in Electronic Production Lines – Best Practices used in Industry"
  - Gives the reader examples of "best practices" of process assessment methodologies and test methods
- Current Cochairs
  - Reinhold Gaertner - Infinion
  - Wolfgang Stadle - Intel

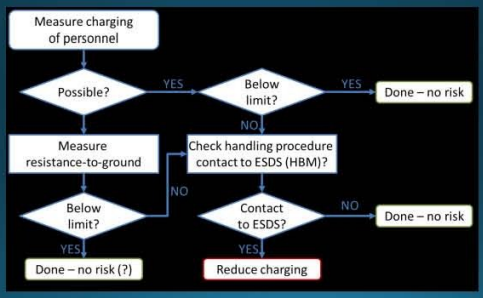
SP17.1-2016: Process Assessment – Measurement Techniques



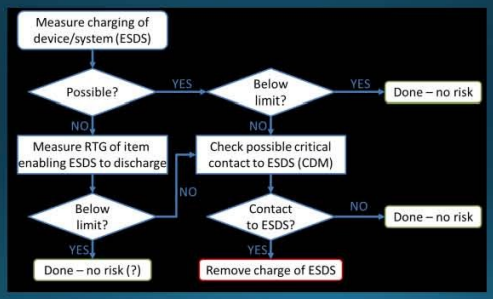
SP17.1-2016: Process Assessment – Measurement Techniques

	Personnel	Conductors	Insulators	Devices/PCBs
Grounding	High-ohm meter	EOS techniques	High-ohm meter	–
Charge	–	Faraday cup	Faraday cup	Faraday cup
Charging voltages	CPM/WKT SVM HIDVM	SVM HIDVM FM	SVM HIDVM FM	SVM HIDVM (FM)
Static fields	FM	FM	FM	FM
Discharge currents	Current probe Pellegrini target (CDM head)	Current probe Pellegrini target (CDM head)	–	Current probe Pellegrini target CDM head
Discharge events	Antenna with oscilloscope Event detector	Antenna with oscilloscope Event detector	–	Antenna with oscilloscope Event detector

SP17.1-2016: Process Assessment – Example: Personnel Charging/Discharging Risk Analysis Flow



SP17.1-2016: Process Assessment – Example: Charging of Devices



Process Capability Example

Acknowledgements:
Stephen Halperin
Ron Gibson

Process Capability & Transitional Analysis Example

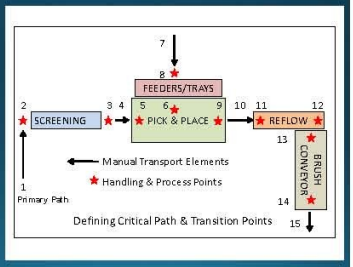
- Define Process Critical Path and Transition Points
- Make Transitional Analysis Measurements
- Summarize Findings

Defining the Critical Path

- A Series of Tasks and Transport Elements (*Transition Points*) Required to Complete a Product or Assembly
  - Starts at Receiving and Ends at Shipping
  - Critical Path and Related Support Activities
  - Examine Entire Path and Support Activities
- *Transition Points* fall into Two Categories:
  - A *Process Function* that Adds Value or Conversion Element to the Device, Subassembly or Product
  - *Transport* from One Task to Another

Case Study Critical Path

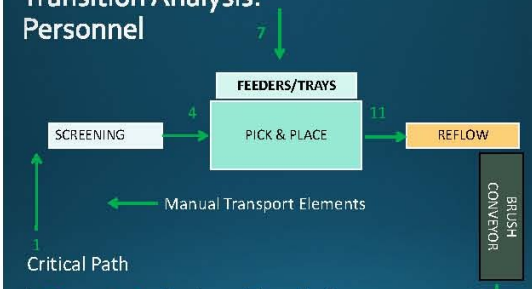
- Process Includes 3 Key Operations:
  1. Board Screening
  2. Parts Installation
  3. Reflow



Case Study Analysis Points

- Personnel Charging
- Printed Circuit Board Screener
- SMT
  - Parts Loading
  - Device Placement
  - Board Movement through Equipment
- Reflow

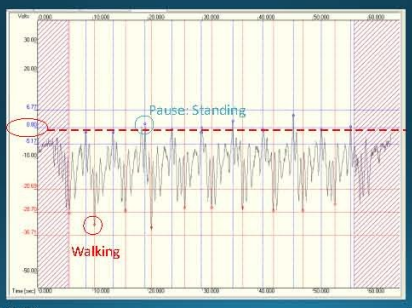
Transition Analysis: Personnel



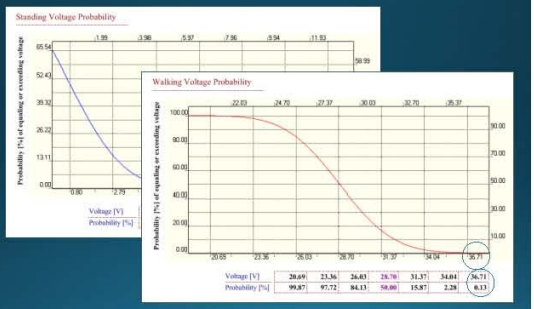
Critical Path

1. *Characterize* Footwear/Floor Performance
2. Then *Measure Manual* Process Transport Elements

Characterizing Footwear/Floor Performance
Data and Probability Analysis



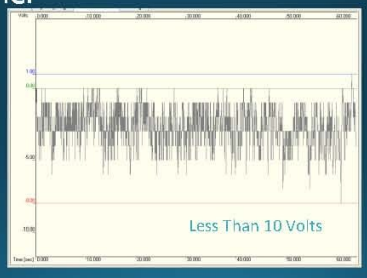
Characterizing Footwear/Flooring Performance
The Probability Analysis



Personnel Voltage: Loading Screener

Range:
+1 Volt

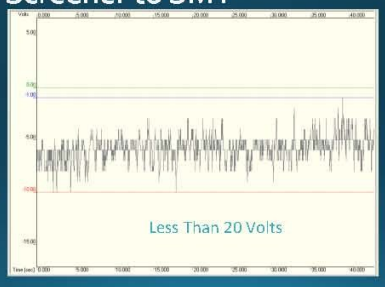
-8 Volts



Personnel Voltage: Transport from Screener to SMT

Range:
-1 Volts

-10 Volts



Personnel Voltage: Personnel Loading Trays Into Feeder

Range:
+2 Volts

-17 Volts

Personnel Charging

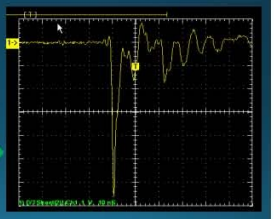
- Summary
  - No Appreciable charging due to personnel

Transitional Analysis: Screener

Screener Analysis

- Raw Board Loading into Screener
  - Use Contact Volt Meter on Conductive Traces
    - Is the Board Charged?
      - If yes, Discharge Trace: CT-1 and Scope
      - Determine Type of ESD threat
- Raw Board Exits Screener
  - Repeat Measurements
- Determine if Further Action Required

Pre-Screening ≤40 Volts
Post Screening -268V
to -441V using CVM



Type Discharge: CDM

Screener Analysis

- Summary:
  - Screening Process Charges Conductive Element(s) of Raw Board
  - Poses possible ESD Discharge Sources during ESDS Placement and Processing if Charge is Not Removed
    - Note: Overhead Ionizer at the Screener's Output can reduce voltage to less than 10 volts

SMT Analysis

- Several items Require Evaluation in this Process Step:
  - Device Transport and Loading In SMT Equipment
    (Feeder Trays and Tape and Reel)
  - Are there Charged Insulators in Equipment than can Cause Field Induced CDM During Placement
  - Does the Placement Equipment Charge Parts Prior to Placement on Board

Transitional Analysis: Feeder

SMT Analysis: Feeder IC Input

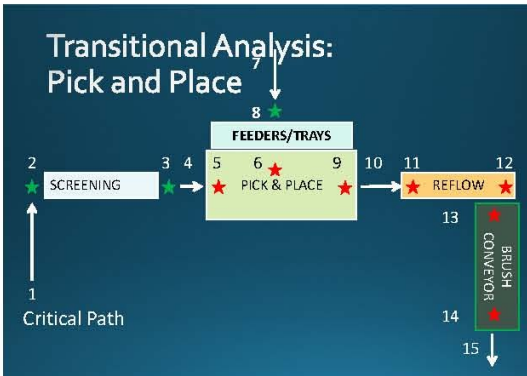
- Trays Loaded into Feeders by Personnel

–Check parts' Voltage After Loading into Feeder (CVM)

- No Voltage was Found

–If Charged, Record Voltage & Verify Discharge Type (CT-1 & Scope)

Transitional Analysis: Pick and Place



SMT Analysis: Pick and Place

- Process Description
  - Screened Boards Loaded by Hand
  - Conveyor Moves Board into Position
  - Machine picks up IC and Places it onto Board
  - Conveyor Moves Board to Machine Exit

SMT Analysis: Pick and Place

- Possible ESD Issues:
  - Static Generators near Placement
  - Isolated, Charged Placement Nozzles
  - Parts Charged from Pick Up Process

Note: We've already Measured Parts to Confirm they are Not Charged Before Pickup

SMT Analysis: Electrostatic Fields at Pick and Place

- To Locate any Static Field Generators Near Placement
  - Send Field Measurement & Recording Device through Equipment 's Critical Path
  - Record Fields that might Exist

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Mount Carrier & Start Recorder

2 Key Factors for Accuracy

Note Space Between CPM & Side Rails

Be Sure Instrument is Properly Grounded

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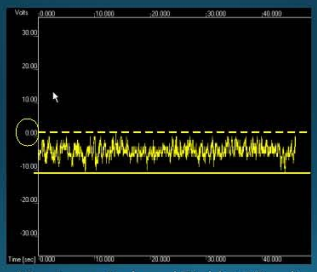
Review Recorded Field Measurements



Maximum Induced Field < 12 volts

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SMT Analysis: Discharges at Pick and Place

- Ensure Parts in Trays are Grounded
- Pick up Part and Place on Stationary CPM
  - Device's Lead Charge is *Shared with CPM*
    - *Charge is Result of Tribocharging Interaction Between Pick up Nozzle and IC device*
    - *One possibility: Keep voltage less than 50 volts*

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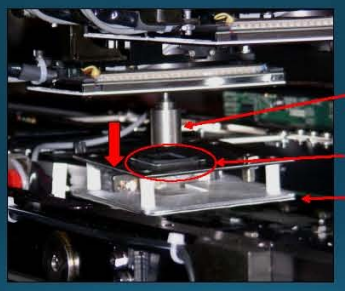

Program Equipment for Device Retrieval & Placement onto CPM

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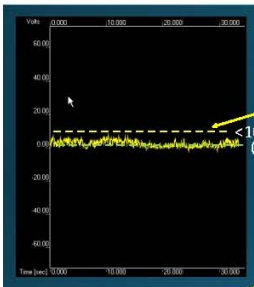
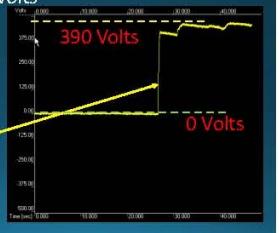


"As-is" Device; No Discharge to Plate

<10 Volts
0 Volts



Confirming Measurement: Artificially Charged Device Discharges to Plate

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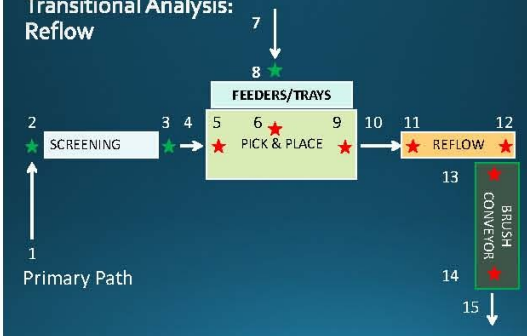
Pick and Place

- SMT Equipment Summary
  - Feeder: IC's and Trays Grounded and Not Charged
  - Electrostatic Fields in Critical Path: Not a Concern
  - Tribocharging Due to IC Handling: Not a Concern

Transitional Analysis: Reflow



Reflow Analysis

- Boards Manually Loaded onto Metal Conveyor
  - Boards from SMT Measured ≈200 volts (Residual Charge from Screener) Before Loading
  - Conveyor is Grounded to Machine Frame (R_{cg})
  - Concern: Are Discharges Occurring between Charged Boards and Grounded Metal Conveyor
    - Boards Measured less than 10 volts After Placement onto Metal Conveyor (Possible ESD Event)
  - Conveyor System Collects Boards after Reflow

Confirming the Discharge Event Repeated Board Loading at Reflow

Discharges Recorded as Boards Enter Reflow

Brush Conveyor Receives Boards ...Then Charges Them

Boards charged to >500 volts

Measured with CVM

Brushes not Dissipative or Grounded

Reflow Analysis: Summary

- Discharges Registered at Loading of Reflow Conveyor
  - Board Charged to 200volts – Residual from Screener Operation
- Reflow Exit Conveyor Charges Boards to greater than 500 volts
  - Possible Discharge to Operators, or at Next Process Step
  - Change Conveyor System or Add Ionization at Post Reflow

Process Analysis Summary

Process Step	Input Voltage	Output Voltage	Within Spec?
Screener	40	268 - 441	No
SMT Feeder Device Input	~ 0	< 50	Yes
SMT Placement	216	95 – 200 V[2]	No
Reflow	Up to 200 V[1,2]	> 500 Volts	No

[1] Residual Voltage from Board Screening Operations
[2] ESD Event Confirmed

Process Analysis Summary

- Measuring Process is Critical for Ultra Sensitive Devices
- All ESD Models can be Found in the Process
  - Measure Charging due to Personnel
  - Measure Charging of Parts
  - Measure any time Parts come into contact with Metal

董树荣

董树荣，2003 年博士毕业于浙江大学信电系电子科学与技术专业，2007 和 2011 年在 UCF 大学访问学者，2009 至 2010 年在英国剑桥大学做研究员，现为浙江大学微纳电子研究所常务副所长，教授博导，IEEE 高级会员，IEEE 电子器件分会 HZchapter 副主席，中华（台湾）静电学会理事，浙江省真空学会理事，江苏艾伦摩尔微电子科技有限公司董事长，浙江大学昆山专用集成电路研究中心主任，浙江省 151 人才、姑苏人才、江苏六大高峰人才等。承担国家 863、国家基金项目、国际合作项目等十多项。发表 SCI/EI 论文 102 篇，国际会议论文 52 篇，授权发明专利 49 项。主要研究领域包括：集成电路可靠性研究、ESD 防护设计、柔性电子器件及系统、MEMS 传感器等。先后为 SMIC、所罗门科技、TSMC 松江、和舰、世纪晶格、炬力、华为、中兴等十多家公司的产品设计过 ESD 防护电路和 30 多家公司做过 ESD 的失效分析，在 IEEE EDS MQ、APFA 等国际会议做 keynotes 报告 2 次；为华虹 NEC 设计的 EEPROM 工艺的 ESD 技术在二代身份证、芯片银行卡等产品领域应用超过 30 亿颗芯片；提出了 CMOS 纳米工艺超薄栅氧击穿新现象和新机理，被英国 Electronics Letters 首页专访 Interview；提出多通道共核 LSCR 和通用 CMOS 工艺的超低电容 TVS 阵列芯片专利技术，并实现 SPW 量产，填补国内产品空白。

Dong Shurong

Shurong Dong was graduated from Zhejiang University as Electronics Engineering PhD in 2003. He was a visiting Professor in UCF EECS department in 2007 and 2011. He was also a research fellow in CAPE of Cambridge University. Now he is vice-director of Microelectronics and Nanoelectronics Institute of Zhejiang University. He is IEEE senior member, IEEE EDS HZ chapter vice-president, China static-electronic society chair, Zhejiang Vacuum society chair, president of Jiangsu AllonMoore microelectronics technology INC, and director of Zhejiang University-Kunshan ASCI center.

He has undertaken ten more projects, including national 863 Plan, national science fund. He has published above 102 SCI/EI papers and 52 international conference papers. He also has 49 patents. His research field includes integration circuit reliability, ESD design, flexible electronics and MEMS sensor. He has deigned 10 more ESD protection circuits for such company as SMIC and Huawei. The EEPROM processing ESD protection technique specially designed for Hua Hong NEC is broadly applied in second citizen identification card and bank IC card, with more than 3 billion chips produced. He also proposed a new Oxide gate breakdown mechanism, which is interviewed by Electronics Letters and published on the first page. He provides a new TVS structure with co-shared LSCR and standard CMOS processing, which is also mass produced as SPW mode and supply the gap domestically.

纳米集成电路静电冲击防护介绍

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Outline

1、ESD基本原理介绍
2、纳米集成电路主要ESD防护器件特点
　2.1 、基本器件
　2.2、可选器件
3、一些遇到的问题
　3.1、高速接口的ESD防护
　3.2、板级和芯片级ESD协同设计
　3.3、新标准JS001/002
　3.4、ESD实验室介绍

1、ESD基本原理介绍

静电ESD危害：不知不觉中损坏IC！

- 湿度40%房间，工人在工作台产生5000V静电，走过地毯产生15000V静电！
- 一般人体可以感知的静电3000-3500V
- 0.18um1.8V RF CMOS栅氧5-7A，ESD击穿电压5-7V

ESD防护：

所幸目前所有芯片都有ESD防护。由于ESD存在在IC的整个寿命中，所以需要分阶段进行ESD防护，如下：

静电控制在500V　　静电控制在2000V

Foundry芯片制造 → 应用！将芯片焊接到电路板 → 用户

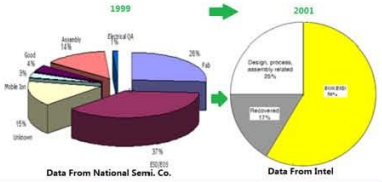
On Chip ESD 防护　　On-Board ESD 防护

1、ESD基本原理介绍

但是因为ESD防护不当：

- 美国国家半导体1998年统计：深亚微米工艺的芯片失效，ESD占37%！
- 美国Intel 2003年统计：65nm工艺芯片失效，，ESD占58%！
- 随着工艺制程的进步，ESD越来越成为芯片主要失效方式！

因此随着工艺制程进步，ESD的研究越来越重要！

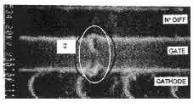


1、ESD基本原理介绍

静电冲击会造成什么损伤？

（1）电流应力造成的失效：

- 例如: 2KV HBM 静电产生 0.91uJ 热，对于一个深亚微米MOS管160*1.2*5um，产生温升2470℃, 对应硅熔点1415℃， Al熔点 660℃!
- 典型失效形式：不均匀导通的焦耳热导致D-S熔丝状损伤、互联线熔断、电荷注入软失效等



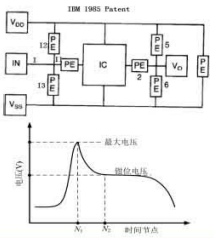
（2）电压应力造成的失效:

- 例如：一般人体可以感知的静电3000-3500V，而0.18um1.8V RF CMOS栅氧5-7A，ESD击穿电压5-7V！
- 典型失效形式：电压过冲导致的栅氧击穿、裂纹扩展软失效等

1、ESD基本原理介绍

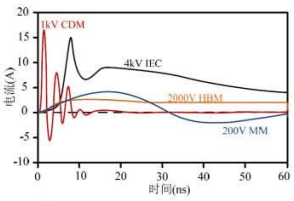
集成电路中ESD防护电路功能：

1. 没有ESD冲击时，ESD防护电路是关闭的和透明的，也就是漏电流和寄生电容小；
2. 当ESD冲击来临时，及时开启：
   - 形成低阻抗通道，导走电流应力，避免ESD主要电流进入芯片内部造击穿；
   - 及时开启钳位电压应力，避免Overshoot电击穿，并将ESD冲击箝位在一定的电压范围内，也就是在整个二次热击穿的范围内，钳位电压保持低于栅氧击穿电压；

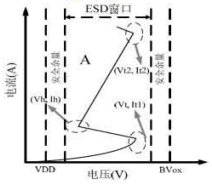


1、ESD基本原理介绍 求是 创新

ESD放电模型



ESD设计窗口



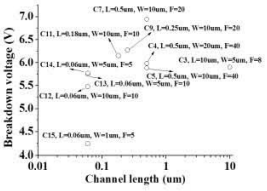
一般来说：
- HBM主要是鲁棒性电流失效，D-S失效
- MM主要能量是4-5个正负脉冲，D-S失效
- CMD主要能量是1正1负电压冲击，栅氧失效

主要参数：
- 触发与开启
- 维持点与抗闩锁
- 导通电阻与箝位电压
- 工作点瞬态功率与热击穿电流

1、ESD基本原理介绍 求是 创新

纳米集成电路ESD挑战（1）：击穿电压BV下降

- 随着制程进步，栅氧减薄，导致栅氧击穿电压BV下降；
- 随着沟道长度缩短，器件击穿或穿通电压下降；
- 当器件尺寸按照design rule的最小尺寸设计时，器件的击穿电压是最低的，所以特别需要关注shrink 工艺比如65nm缩到55nm，45纳米缩到40nm的工艺。

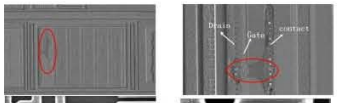


Data from ESD Lab of Zhejiang University

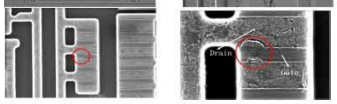
1、Introduction 求是 创新

- For Example: most failures are gate breakdown in 40nm process

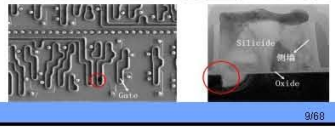
HBM ESD Failure



MM ESD Failure

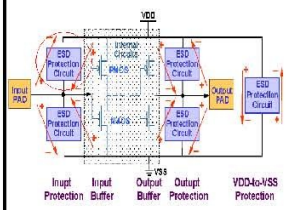


CDM ESD Failure

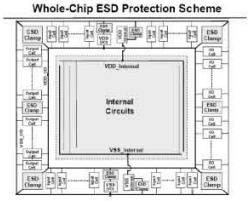


1、Introduction 求是 创新

- ESD happen at every way, direction, place and time!
- ESD should be designed carefully : Bi-dircetion, high open speed …



Whole-Chip ESD Protection Scheme



1、ESD基本原理介绍 求是 创新

纳米集成电路ESD挑战（2）：互联线压降

随着制程进步和集成度增加，互联线的压降增加（如下），同时IC的工作电压下降，这样降在互联线的分压比会变得非常显著！导致IC工作点变化和ESD防护电路触发困难。

Vi/o= Iesd * (Ron + Rvdd + Rvss + Rpc)+Vpc+Von，　$R_{metal} = \frac{\rho L}{WT}$

Metal L	DC Rdc	Voltage drop under 2KV HBM
30um	0.11Ω	0.15V
500um	1.83Ω	2.43V
1500um	5.5Ω	7.315 V

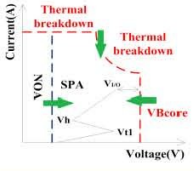
40nm工艺Core电压1.8V，I/O电压3V；28nm工艺Core电压1.3V，I/O电压2.2V

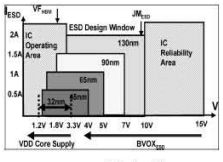
Data from ESD Lab of Zhejiang University

1、ESD基本原理介绍 求是 创新

纳米集成电路ESD挑战（3）：ESD设计窗口变窄

ESD设计窗口变的非常窄，比如45nm工艺中ESD design windows 只有1.4-3.8V（I/O和内核不同）。这对于ESD防护器件设计带来巨大挑战。因为ESD防护器件工作在雪崩区，器件雪崩后还要保证钳位电压变化在1-2V很难。目前技术很难做到准确的仿真，更多是凭借经验值。





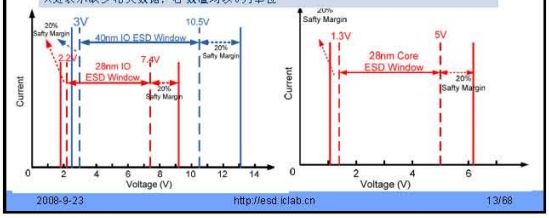
Data from TI

1、ESD基本原理介绍 求是 创新

国内著名厂家工艺的ESD窗口

	Core Device			IO Device		
	Working	DC BV	TLP BV	Working	DC BV	TLP BV
40nm	1.1	X	6	2.5	X	13.1
28nm PS	1.05	X	6	1.8	X	9
28nm HK	0.9	2.8	6.2	1.8	5.2	9.3

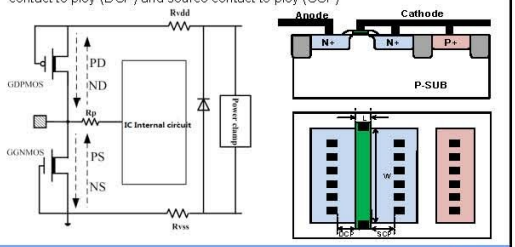
X处表示缺少相关数据；各数值均以V为单位



Outline 求是 创新

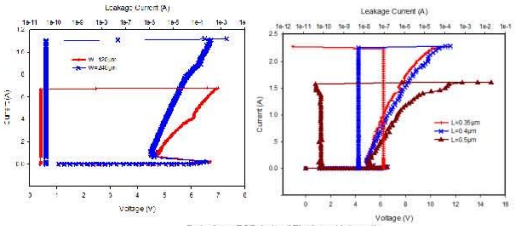
2.1、Basic Device ——GGNMOS 求是 创新

- GGNMOS is widely applied in IC ESD protection owing to its simple structure!
- GGNMOS key structure parameters: channel width (W), channel length (L), drain contact to ploy (DCP) and source contact to ploy (SCP)



2.1、Basic Device ——GGNMOS 求是 创新

TLP results of GGNMOS in 65nm CMOS process with different W & L



Data from ESD Lab of Zhejiang University

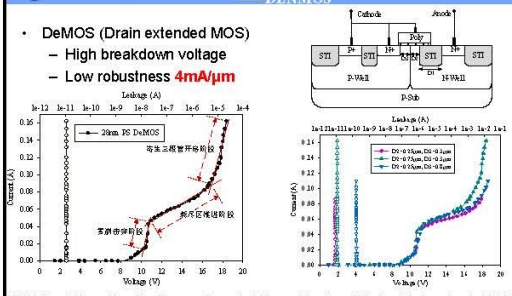
2.1、Basic Device ——GGNMOS 求是 创新

Design ruler : (different from deep-sub-micro process ESD protection)

- The key of the 40nm process ESD are very narrow ESD window and low BV of thin oxide thickness. The W, effected on trigger voltage and holding voltage, should be mainly consider. L is no longer the main factor to affect the failure current.
- 90nm and 65nm process: the W mainly effect on the uniformity of current. Small L will achieve an excellent failure current, while it also has low holding voltage. Setting L should be trade off.
- DCP increasing will improve current uniformity so as to increase It2, because of DCP as a ballast resistor. The best DCP for ESD protection is different under different process. SCP is minor compared to DCP
- Both DCP & SCP have a little effect on the trigger voltage and holding voltage.

2.1、Basic Device ——DENMOS 求是 创新

- DeMOS (Drain extended MOS)
  - High breakdown voltage
  - Low robustness **4mA/μm**



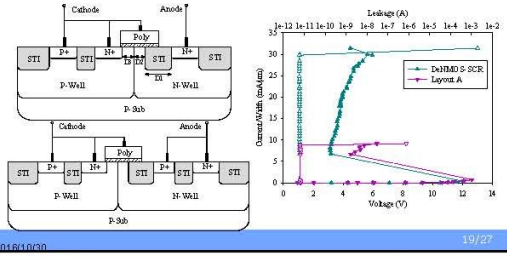
[1] Weihuai Wang, Hao Jin, Shurong Dong, Lei Zhong, Yan Han, "Study of drain-extended NMOS under electrostatic discharge stress in 28 nm and 40 nm CMOS process," Solid-State Electronics, vol. 116, pp. 80-87, Feb 2016.

2.1、Basic Device ——DENMOS

求是 创新

❖ **DeMOS-SCR**

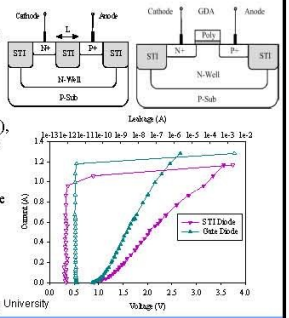
- **Insert long P+ into Drain N+ to form embeded SCR to improve robustness to 16mA/um**



2.1、Basic Device ——Diode

求是 创新

- Diode is always used in low voltage IC ESD protection
- Diode has low trigger voltage (0.7V), some leakage and turn-on resistance
- A kind of Gate diode can be improve its turn-on

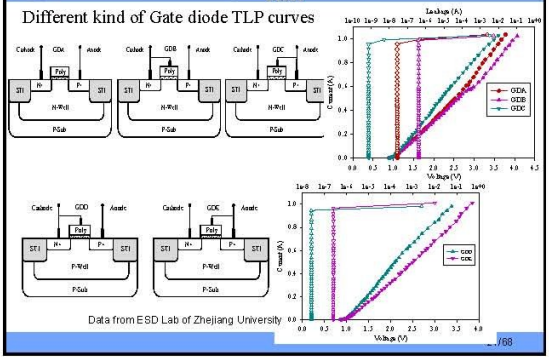


Data from ESD Lab of Zhejiang University

2.1、Basic Device ——Diode

求是 创新

Different kind of Gate diode TLP curves

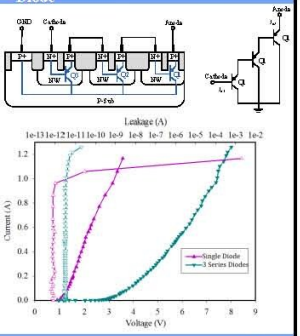


Data from ESD Lab of Zhejiang University

2.1、Basic Device ——Diode

求是 创新

- Diodes in series can meet different voltage demand.
- Owing to Darlington effect, the leakage will increase and voltage increasing will be weaken with the number of Diodes in series.
- It can be improved by retrograde well process

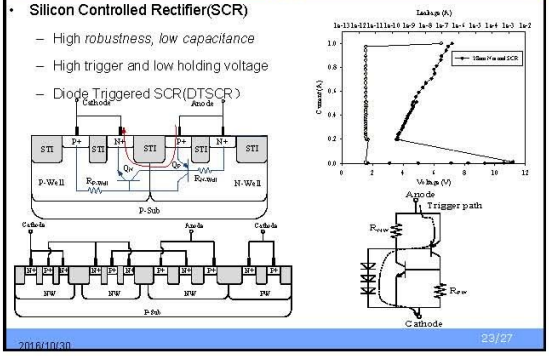


Data from ESD Lab of Zhejiang University

2.1、Basic Device ——SCR

求是 创新

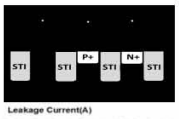
- Silicon Controlled Rectifier(SCR)
  - High *robustness, low capacitance*
  - High trigger and low holding voltage
  - Diode Triggered SCR(DTSCR)

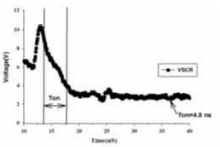


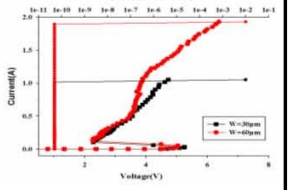
2.1、Basic Device ——SCR

求是 创新

- Vertical SCR，VSCR)
  - Low trigger 5.3V and high holding 2.3V
  - High robustness，33mA/μm
  - turn-on time 4.8ns

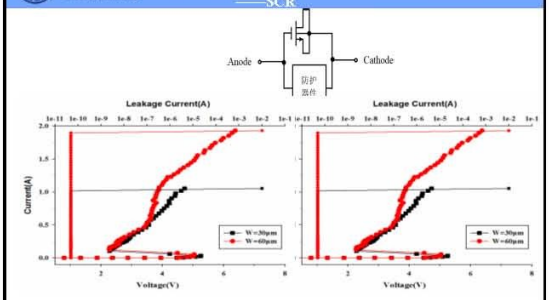






2.1 、Basic Device ——SCR

求是 创新



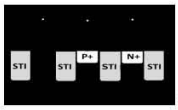
Meet the ESD windows of 40/28nm Core

2.1 、Basic Device ——SCR

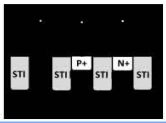
求是 创新

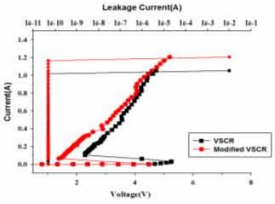
- Modified VSCR
  - Low trigger 4.5.3V and high holding 1.4V
  - High robustness，40mA/μm

VSCR



Modified VSCR





Outline

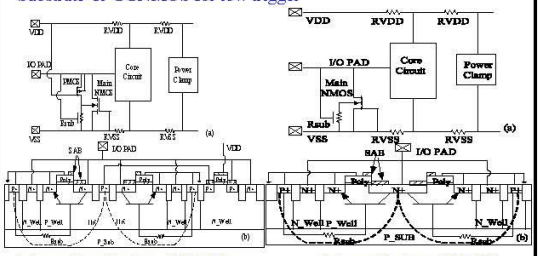
求是 创新

1、ESD基本原理介绍
2、纳米集成电路主要ESD防护器件特点
　2.1 、基本器件
　2.2、可选器件
3、一些遇到的问题
　3.1、高速接口的ESD防护
　3.2、板级和芯片级ESD协同设计
　3.3、新标准JS001/002
　3.4、ESD实验室介绍

Candidates（1）

求是 创新

Substrate-Tr GGNMOS for low trigger



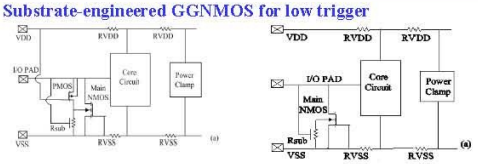
Substrate R and I trigger GGNMOS　　Substrate R trigger GGNMOS

S. Dong, et.l, Substrate-engineered GGNMOS for low trigger voltage ESD in 65nm CMOS process, Microelectronics Reliability, Volume 51, Issue 12, December 2011, Pages 2124-2128.

Candidates（1）

求是 创新

Substrate-engineered GGNMOS for low trigger



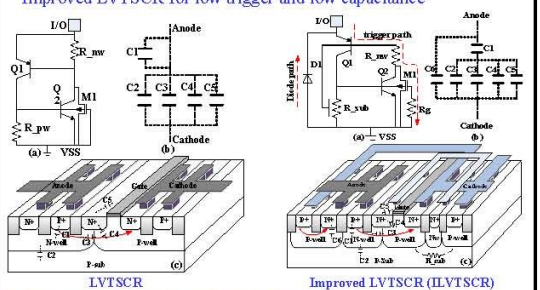
Substrate R and I trigger GGNMOS　　Substrate R trigger GGNMOS

	It2(A)	Vt1(V)	C(pF)	It2/area (mA/um2)
GGNMOS	2.13	6.84	0.652	2.5
Substrate R trigger GGNMOS	2.07	5.3	0.788	2.17
Substrate R and I trigger GGNMOS	2.63	3	0.891	2.33

Candidates（2）

求是 创新

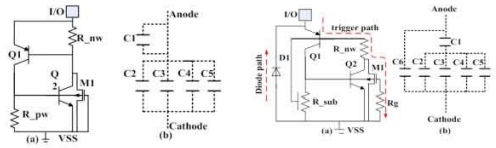
Improved LVTSCR for low trigger and low capacitance



LVTSCR　　Improved LVTSCR (ILVTSCR)

S. Dong, "Improved Low Voltage-Triggered SCR Structure for RF-ESD Protection," Electron Device Letters, IEEE , vol.34, no.8, pp.1050,1052, Aug. 2013.

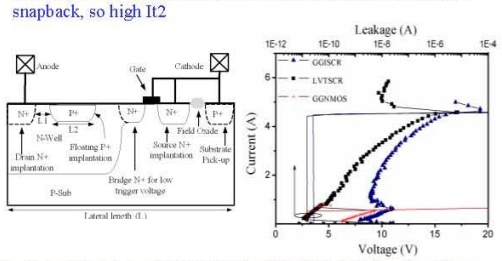
Candidates（2）　求是 创新



Structures	Area /μm²	Vt1 /V	It2 /A	C_{ESD} /fF	I_{leak} /nA
GGNMOS	17*50	7.3	2.13	652	0.9
LVTSCR	6*50	7.5	1.82	130	0.35
DTSCR	12*50	2.5	1.93	96	120
ILVTSCR	9*50	2.2	1.9	50	0.3

Candidates（3）　求是 创新

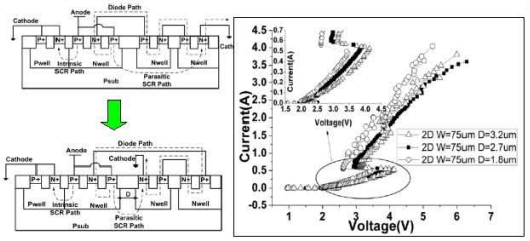
Floating P+ LVTSCR for high holding voltage, which has two snapback, so high It2



S. Dong, "Design and Analysis of an Area-efficient High Holding Voltage ESD Protection Device," IEEE Transaction on Electron Device, 2014,6

Candidates（4）　求是 创新

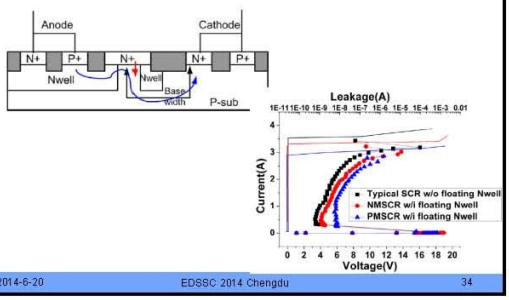
Improved Diode trigger SCR meet 1.8-2V ESD design windows, which also has two snapback



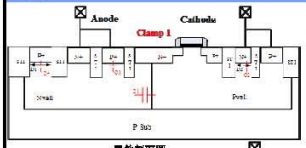
S. Dong, "Minimizing Multiple Triggering Effect in Diode-Triggered Silicon Controlled Rectifier (SCR) for ESD Protection Applications," IEEE Electron Device Lett.,2012,11

Candidates（5）　求是 创新

Improved MLSCR with floating N-well to increasing holding



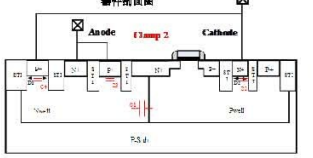
Candidates（6）　求是 创新

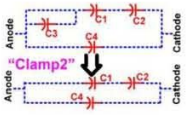


LCSCR，Low Capacitance Silicon Controlled Rectifier。

Clamp 1 traditional device

Clamp 2 is LCSCR

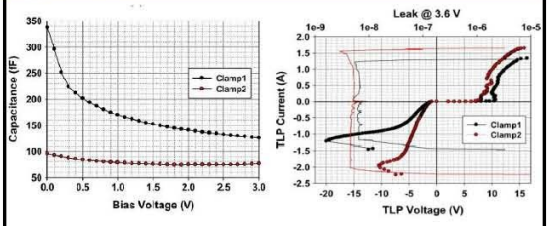




LCSCR capacitance

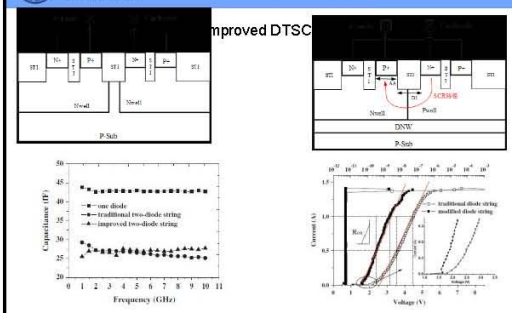
Q. Cui, J.A. Salcedo et al, "high robustness and low-capacitance silicon-controlled rectifier for high speed io esd protection," IEEE Electron Dev. Let. Vol. 34 NO. 2, 2013, pp. 178-180

Candidates（6）　求是 创新



Candidates（7）　求是 创新

mproved DTSC



F. Ma, Y. Han, S. Dong, L. Zhong, H. Liang and F. Gao, "Improvement on diode string structure for 65-nm RF ESD protection," Solid-State Electron, Vol. 89, 2013, pp. 142-145

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Outline　求是 创新

1、ESD基本原理介绍
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　3.3、新标准JS001/002
　3.4、ESD实验室介绍

2014-6-20　EDSSC 2014 Chengdu　38

高速接口问题（1）--寄生电容　求是 创新

◆高速数据传输业务常用的低摆幅、低功耗及优异噪声性能的三种信号接口：
- PECL (Positive Emitter-Coupled Logic)
- LVDS (Low-Voltage Differential Signals)
- CML (Current Mode Logic)。

例如：LVDS低压差分信号，高速串行低摆幅差分信号，一般655Mbps。CML的速率更高，可达10Gbps。

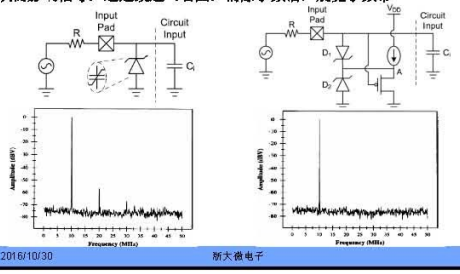
对寄生电容要求：
◆寄生电容更小
◆信号直流分量导致电容变化要小
◆ESD防护电路引入的RC信号失真在允许范围内

2016/10/30　浙大微电子　39

高速接口问题（1）--寄生电容　求是 创新

12 bit 20 MS/s A/D converter

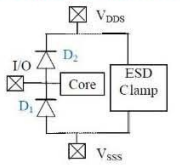
■ 左图为齐纳二极管防护，其电容会随着信号摆幅出现不同的偏置电容值，从而影响信号，通过改进（右图）消除了频谱，展宽了频带



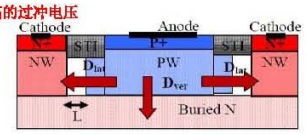
2016/10/30　浙大微电子　40

高速接口问题（2）--overshoot　求是 创新

◆高速接口应用要求：二极管的寄生电容非常小（100-30 fF）
◆导致的负面影响：产生较高的过冲电压



典型I/O接口ESD防护电路图



二极管寄生电容：
◆二极管电流分为横向和纵向两个方向
◆通过合理调节NW和PW的参杂浓度来获得较小的寄生电容

F. Farbiz, A. Appaswamy, A.A. Salman and G. Boselli, "Overshoot-induced failures in forward-baised diodes: a new challenge to high-speed ESD design." IRPS, 2013. **(Texas Instruments Inc.)**

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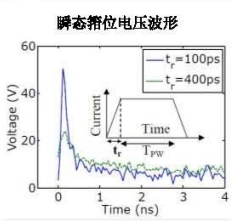
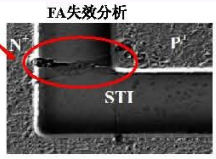
HDMI接口失效案例　求是 创新

瞬态箝位电压波形



失效点

FA失效分析



由过冲电压引起的热失效图

◆TLP脉冲上升沿越快，会引起越高的过冲电压，导致失效电流越低

	Rise-time t_r (ns)	I_{T2} (A)
VF-TLP (T_{PW}=10ns)	0.1	5.96
	0.4	7.74
TT-P (T_{PW}=100ns)	2	5.49
	10	7.2

◆这种失效模式特别容易由IEC和CDM引起

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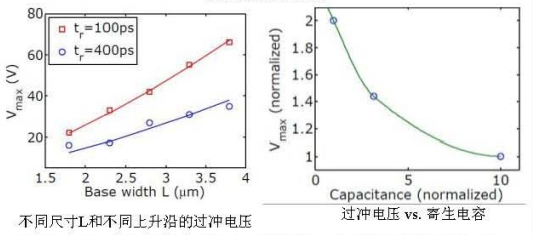
HDMI接口失效案例

求是 创新

器件综合对比评估



不同尺寸L和不同上升沿的过冲电压　　过冲电压 vs. 寄生电容

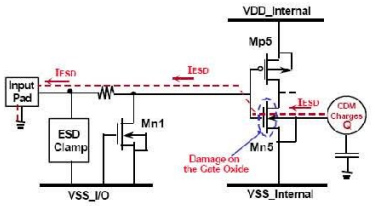
◆器件的参数L越长，过冲电压越高，这个现象对上升沿越快的脉冲越明显

◆越小的寄生电容会导致越高的过程电压，这需要在设计时折中考虑

高速接口问题（3）——CDM损伤

求是 创新

ESD Damages Due to CDM ESD Events

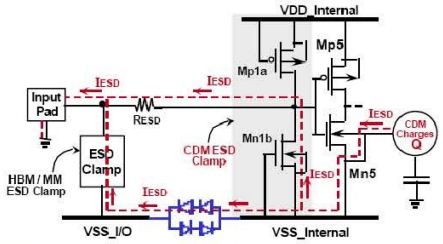


The ESD protection circuit at the input pad can provide effective ESD protection against the HBM and MM ESD events, but it can not provide effective ESD protection against the CDM ESD events.

高速接口问题（3）——CDM损伤

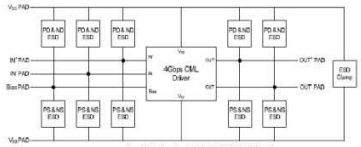
求是 创新

ESD Protection for CDM ESD Events

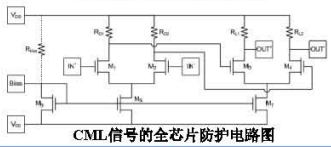


高速接口问题（4）-差分信号放大器

求是 创新



CML信号的全芯片防护框图

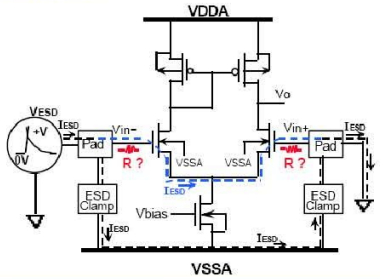


CML信号的全芯片防护电路图

高速接口问题（4）-差分信号放大器

求是 创新

- ESD voltage is across the gate oxides of the different-pair input stage of an Operational Amplifier.



Outline

求是 创新

1、ESD基本原理介绍
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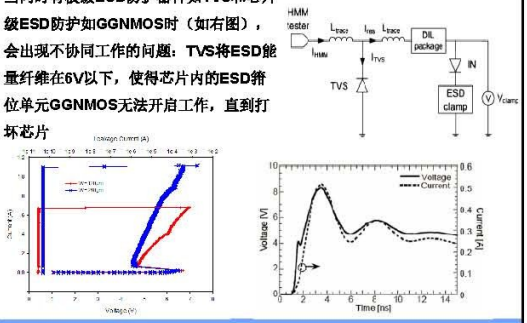
　　2.1 、NMOS
　　2.2 、Diode
　　2.3、SCR
　　2.4、可选器件
3、一些遇到的问题
　　3.1、高速接口的ESD防护
　　3.2、板级和芯片级ESD协同设计
　　3.3、新标准JS001/002
　　3.4、ESD实验室介绍

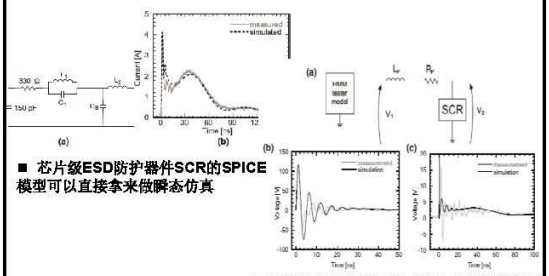
3.2、板级和芯片级ESD协同设计 求是 创新

■ 当同时有板级ESD防护器件如TVS和芯片级ESD防护如GGNMOS时（如右图），会出现不协同工作的问题：TVS将ESD能量钳维在6V以下，使得芯片内的ESD箝位单元GGNMOS无法开启工作，直到打坏芯片



3.2、板级和芯片级ESD协同设计 求是 创新

Onchip的ESD和TVS的SPICE模型可以直接拿来做瞬态仿真

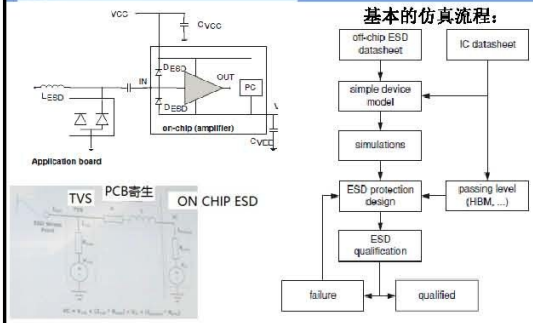


■ 芯片级ESD防护器件SCR的SPICE模型可以直接拿来做瞬态仿真

■ TVS的SPICE模型可以直接拿来做瞬态仿真

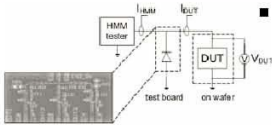
3.2、板级和芯片级ESD协同设计 求是 创新

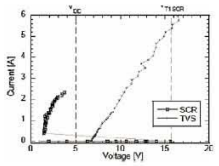
基本的仿真流程：



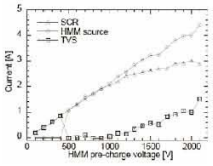
3.2、板级和芯片级ESD协同设计 求是 创新

■ 板级TVS+芯片级SCR的ESD防护设计案例：可以看出TLP（HBM）脉冲下，SCR无法开启，HMM（IEC）下SCR与TVS协作开启。





100ns的TLP冲击实测结果



30ns的HMM冲击实测结果

Outline 求是 创新

3.3、新标准JS001/002 求是 创新

● 考虑到ANSI、ESDA以及JEDEC诸多标准的统一，2012年和2014年分别提出了融合上述三家标准的JS001-2012及改进版JS001-2014（均可以网上下载）。主要参考的标准包括：ANSI/ESDA/JEDEC JS-001-2010 and subsequent versions, ANSI/ESD STM5.1-2007, or JESD22-A114F, ESD ADV1.0, ESD Association's Glossary of Terms1 JESD99, JEDEC Standard - Terms, Definitions, and Letter Symbols for Microelectronic Devices2。

需要关注的几点：

1. 提出了failure window

参考了我们的建议，提出了ESD失效窗口failure window概念。标准中的例子：IC通过了500VHBM.没通过1000VHBM，通过了2000VHBM，那么IC的ESD失效窗口是500V-2000VHBM，IC的ESD等级2是500VHBM

3.3、新标准JS001/002　求是 创新

2. 统一测试方法和参数：

- 从低压测到高压，起始电压为70%标称电压开始，到第一个PIN失效的电压值定义为IC的VESD
- 考虑ESD耐受性，单向步进，当小于1000V时步进50V(100V)，大于1000V时步进100V(250V, 500V)
- 失效判据：例如漏电流增加十倍以上、I-V曲线或阈值电压飘5%(或10%)等
- 测试方法一秒一次，间隔1秒，可以步进打，也可以轮打。

最短间隔时间和测试次数

	HBM	MM
Mil-883	1秒, 3次	
ESDA	0.3秒, 1次	1秒, 3次
JEDEC	0.1秒, 1次	0.5秒, 1次
AEC	0.5秒, 1次	1秒, 1次

3.3、新标准JS001/002　求是 创新

3. 提出了Human Body Model Simulator

考虑到目前测试的一些问题，特别是步进放电中电荷积累的问题、测试板（SOCKET）寄生问题以及尾波脉冲问题，提出了如下的方法：（1）电荷消除电路；（2）测试板（SOCKET）标定；（3）标准负载标定等

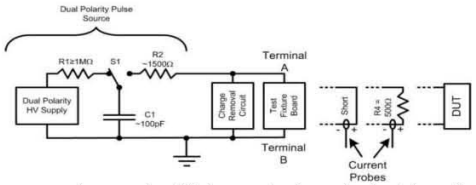


Figure 1: Simplified HBM Simulator Circuit with Loads

3.3、新标准JS001/002　求是 创新

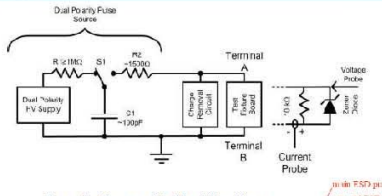
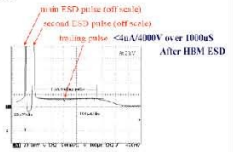


Figure 5: Diagram of Trailing Pulse Measures



Trailing Pulse (尾波) 示意图，0.13um 或更小间程工艺要考虑

Outline　求是 创新

1、ESD基本原理介绍
2、纳米集成电路主要ESD防护器件特点
　2.1 、NMOS
　2.2 、Diode
　2.3、SCR
　2.4、可选器件
3、一些遇到的问题
　3.1、高速接口的ESD防护
　3.2、板级和芯片级ESD协同设计
　3.3、新标准JS001/002
　3.4、ESD实验室介绍

ESD实验室介绍　求是 创新

- 浙江大学ESD实验室是国内第一家专业从事芯片级ESD研发工作的实验室。在国内芯片级ESD领域具有权威地位。具有完善的测试体系和丰富的研究经历，在国际上具有知名度。实验室设备包括：Barth 4002 TLP测试系统、E-GUN+示波器、HP5100B半导体测试仪、Vector DC/RF探针台、ADVAN/HP矢量网络分析仪、SEM/EDA等FA仪器及其他设备，CAD/EDA工作站、服务器及TCAD仿真软件工具TSUPREM-4/MEDICI, ISE-TCAD，SILVACO等。

ESD实验室介绍　求是 创新

主要业绩

- 对外提供ESD设计、失效分析和测试服务36家297次；
- 发表SCI论文56篇，其中TED/EDL论文18篇，出版专著3部，申请发明专利59项授权41项；

合作企业包括：
士兰微电子股份有限公司、矽力杰半导体技术有限公司、杭州立昂电子有限公司 、绍兴恒力特微电子有限公司、清华大学微电子所、北京大学微电子所 、北京昆腾微电子有限公司 、中国科学院上海技术物理研究所、上海力芯集成电路制造有限公司、上海芯奥电子科技有限公司、上海神沃电子有限公司、上海新进半导体制造有限公司、上海先进半导体制造有限公司、灿瑞半导体上海有限公司、复旦微电子、东南大学、南京理工大学、江苏长电科技股份有限公司、江苏东光微电子股份有限公司、苏州晶讯科技股份有限公司 、无锡芯朋微电子有限公司、华润上华科技有限公司、华为、中兴通信、比亚迪、珠海炬力、深南电路有限公司、广州中星半导体公司、长虹公司、电子科技大学、武汉吴宏微电子有限公司、武汉芯景科技有限公司、湘潭大学、香港科技研究院等

ESD实验室介绍　求是 创新

典型应用案例

① 对外提供ESD设计服务21次，ESD失效分析和测试服务36家297次，ESD培训服务6次合计450人次，在业界具有较高知名度；

② 为华虹NEC设计的EEPROM工艺的全芯片ESD技术，广泛应用在目前二代身份证（解决了二代证量产关键难题）、SIM卡、射频卡以及芯片银行卡等产品上，用量超过30亿颗芯片；

③ 为华为设计的35Gbps GaAs高速接口、USB3.1 typeC、VBO、HDMI1.4等芯片的ESD防护，解决了高速接口超低电容ESD防护难题；

④ 微复旦微电子设计的RF IC射频卡ESD，性能超过国际同类产品；

⑤ 设计的超高FOM双向互补电容耦合SCR，被TSMC松江厂用在HVCMOS工艺中，被晶门科技用在液晶显示驱动芯片产品中（其产量占全球21%）；

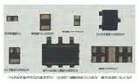
⑥ 为国产PDP显示屏行驱动芯片（长虹）提供ESD设计，获十一五核高基重大专项“基于自主知识产权的PDP显示控制和驱动芯片 开发与产业化”资助；

ESD实验室介绍　求是 创新

典型应用案例

⑦ 主持中芯国际65~28nm工艺ESD研究，提出多项专利技术，将箝位电压限制在5.6V@8KV内（业界最高指标），解决SMIC的28/45nm工艺量产关键难题；成果受到国际关注，在2014 IEEE EDSMQ会议做keynotes报告，发表TED、EDL论文9篇；

⑧ 提出多通道共核LSCR和通用CMOS工艺的TVS阵列芯片专利技术，受邀APFA2010和2015 IEEE EDSMQ会议Keynotes发言，已授权发明13项，掌握自有知识产权，实现SPW量产，填补国内产品空白；



ESD实验室介绍　求是 创新

典型理论成果

① 提出了JEDEC2003国际标准的漏洞和改进建议（发表在IEEE Trans. on Dev. MR），被美国科技新闻网站誉为“new finding on science”，JS002新标准基于此提出“ESD失效窗口”

② LDMOS 在ESD冲击下雪崩饱和新机理的研究获得英国Electronics Letters期刊作为亮点报道

ESD实验室介绍　求是 创新

典型理论成果

③ 超薄栅氧ESD击穿新现象和新机理发表在JAP和APL上，获得国际关注；集成电路可靠性权威法国里尔大学Steve Arscott教授Rreview中提及本成果是一个有意义的研究；德国飞利浦创新中心Holger Spahr博士正面引用本机理研究了high K介质可靠性；

④ 提出了石墨烯与金属热电失效机理，获得英国皇家学会RSC Advances的“Top 10 most accessed articles in March”。

⑤ 揭示石墨烯超强ESD鲁棒性，因为观点新颖获得英国Electronics Letters首页专访Interview。

求是 创新

Thank You

欢迎联系和交流！
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ESD Protection in Nanometer CMOS Process

Shurong Dong

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Zhejiang University
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Outline

1、Basic principle of ESD design
2、Main devices for Nanometer CMOS Process
　2.1 、Basic Devices：
　2.2、Some good candidates
3、Design for Nanometer CMOS circuit
　3.1、Key concerned
　3.2、System Efficient ESD Design (SEED)
　3.3、New standard JS001/002

1、Introduction

- **ESD easily demages IC.** For example, worker on the bench will produce 5000V ESD, person can perceive above 3500V ESD, IC can be demaged by ESD under ~10V.
- **ESD happens in anytime and any stage! So protection should be in IC whole lifetime.**
- **Two ways to implement ESD protection according to different stages**

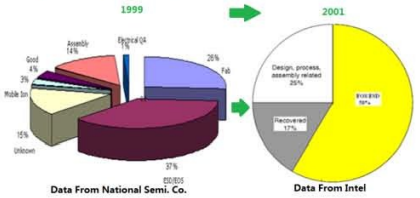
IC Fabrication in Fab → IC mount on PCB board → Custom using Produce with IC

On-Chip ESD protection, such as GGNMOS

On-board ESD Protection, such as TVS

1、Introduction

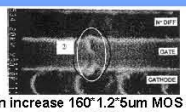
- **Every IC has ESD protection. However ESD failure is still main way of IC failure: 37% in deep submicron process (1999 NS) and 58% in 130-90nm process (2001 Intel)**



- **With the processing developing, ESD is becoming serious problem!**

1、Introduction

How ESD stress damage IC?



（1）Current stress:

For Example:
2KV HBM stress produce 0.91uJ heat, it can increase 160°1.2°5um MOS temperature to 2470℃, compared with Si melting Point 1415℃， Al's 660℃!

Typical Failure: D-S silicon filament or metal interconnect melt due to joule heating

（2）Voltage stress:

For example:
Gate Oxide breakdown field E is8-10MV/cm. As to 0.18um/1.8V RF CMOS processing，its Gate Oxide breakdown voltage is below 4-5V，compared with human body recognized ESD voltage 3500V

Typical Failure: gate oxide films breakdown

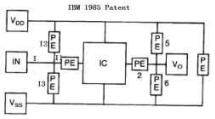
1、Introduction

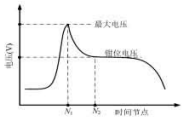
So， How to designed ESD protection：

（1）Transparent during IC working normally;

（2）During ESD happening，ESD protection circuit should:

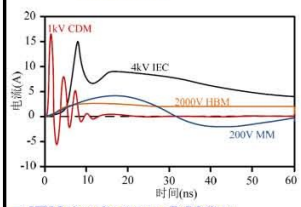
- **Form a low resistence way by pass ESD current stress, so as to avoid ESD current stress flow into IC internal.**
- **Clamp overshoot and ESD voltage stress to avoid gate breakdown!**





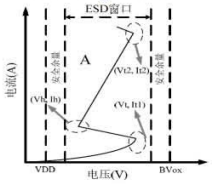
1、Introduction　求是 创新

ESD model



- HBM: its robustness as D-S failure
- MM: 4-5 ring P/N pulse as D-S failure
- CMD: 1 P and 1 N pulse as gate breakdown
- IEC

ESD design window

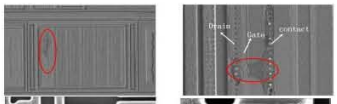


- Trigger voltage and current
- Holding voltage and current
- Turn-on resistent and speed
- Second break down current

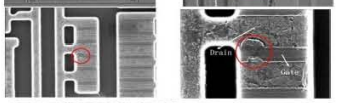
1、Introduction　求是 创新

- For Example: most failures are gate breakdown in 40nm process

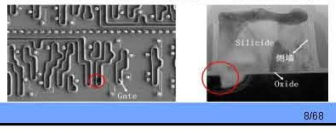
HBM ESD Failure



MM ESD Failure



CDM ESD Failure



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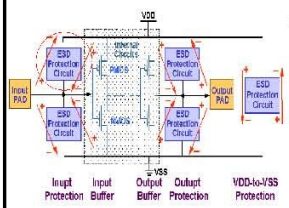
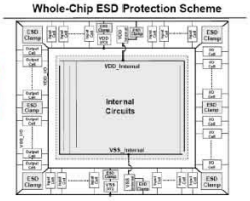
1、Introduction　求是 创新

- ESD happen at every way, direction, place and time!
- ESD should be designed carefully : Bi-dircetion, high open speed …



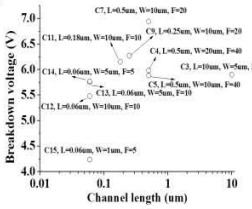
Whole-Chip ESD Protection Scheme



1、Introduction　求是 创新

Challenge (1)： Break down voltage decrease in ESD for nanometer process

- Gate Break down voltage decrease with the thinner gate appear;
- MOS Break down or punchthrough owing to channel length decrease;
- Device has a lowest breakdown voltage with smallest L in design rule of shrink process, for example 65nm to 55nm，45 to 40nm.



Data from ESD Lab of Zhejiang University

2008-9-23　http://esd.iclab.cn

1、Introduction　求是 创新

Challenge (2) voltage drop on the interconnect

Owing to high integration, interconnect become long and voltage drop on the interconnect increase, while IC working voltage decrease. As results, The IC working point drift and ESD protection trigger difficulty

$$Vi/o = Iesd * (Ron + Rvdd + Rvss + Rpc) + Vpc + Von, \quad R_{metal} = \frac{\rho L}{WT}$$

Metal L	DC Rdc	Voltage drop under 2KV HBM
30um	0.11Ω	0.15V
500um	1.83Ω	2.43V
1500um	5.5Ω	7.315 V

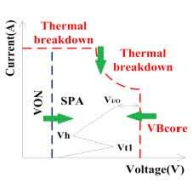
compared with 40nm Core 1.8V，I/O 3V；28nm Core 1.3V，I/O 2.2V

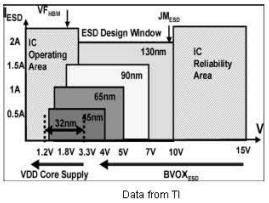
Data from ESD Lab of Zhejiang University

2014-6-20　EDSSC 2014 Chengdu　11

1、Introduction　求是 创新

(3) ESD design windows shrinks obviously! Design becomes very difficult. Especially, ESD devices clamp voltage under avalanche breakdown working state.





Data from TI

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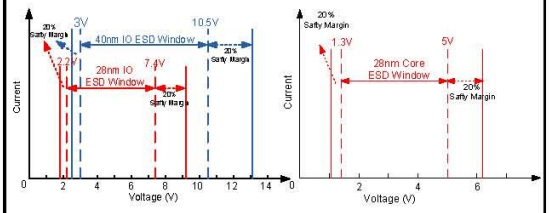
1、Introduction

求是 创新

ESD design wondows in SMIC



40nm Process and 28nm Process ESD design windows

Data from ESD Lab of Zhejiang University

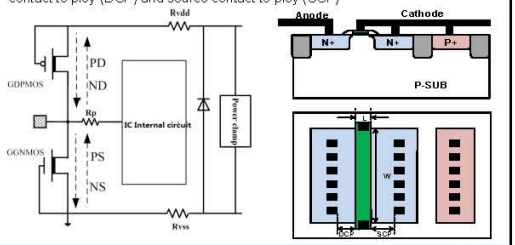
Outline

求是 创新

2.1 、Basic Device ——GGNMOS

求是 创新

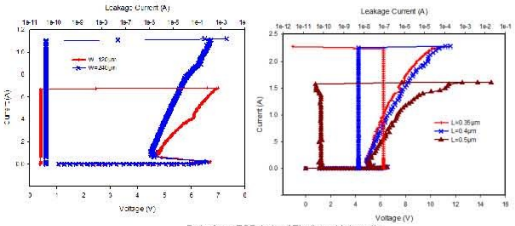
- GGNMOS is widely applied in IC ESD protection owing to its simple structure!
- GGNMOS key structure parameters: channel width (W), channel length (L), drain contact to ploy (DCP) and source contact to ploy (SCP)



2.1 、Basic Device ——GGNMOS

求是 创新

TLP results of GGNMOS in 65nm CMOS process with different W & L



Data from ESD Lab of Zhejiang University

2.1 、Basic Device ——GGNMOS

求是 创新

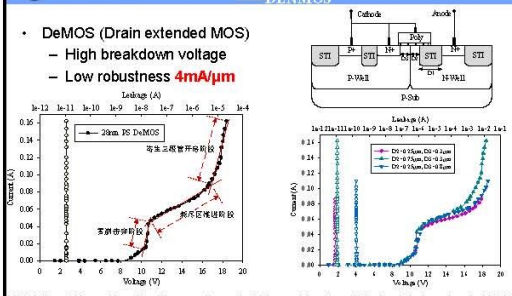
Design ruler : (different from deep-sub-micro process ESD protection)

- The key of the 40nm process ESD are very narrow ESD window and low BV of thin oxide thickness. The W, effected on trigger voltage and holding voltage, should be mainly consider. L is no longer the main factor to affect the failure current.
- 90nm and 65nm process: the W mainly effect on the uniformity of current. Small L will achieve an excellent failure current, while it also has low holding voltage. Setting L should be trade off.
- DCP increasing will improve current uniformity so as to increase It2, because of DCP as a ballast resistor. The best DCP for ESD protection is different under different process. SCP is minor compared to DCP
- Both DCP & SCP have a little effect on the trigger voltage and holding voltage.

2.1 、Basic Device ——DENMOS

求是 创新

- DeMOS (Drain extended MOS)
  - High breakdown voltage
  - Low robustness **4mA/μm**



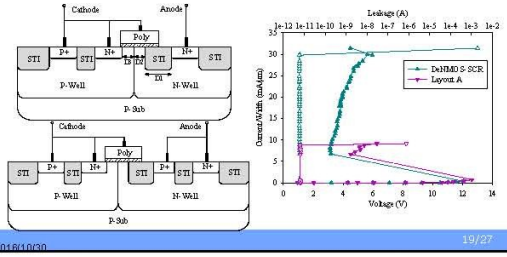
[1] Weihuai Wang, Hao Jin, Shurong Dong, Lei Zhong, Yan Han, "Study of drain-extended NMOS under electrostatic discharge stress in 28 nm and 40 nm CMOS process," Solid-State Electronics, vol. 116, pp. 80-87, Feb 2016.

2.1、Basic Device ——DENMOS

求是 创新

❖ **DeMOS-SCR**

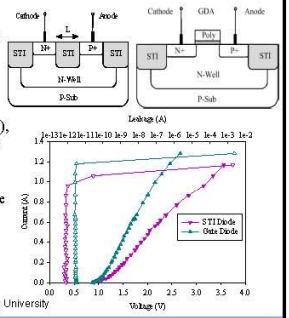
- **Insert long P+ into Drain N+ to form embeded SCR to improve robustness to 16mA/um**



2.1、Basic Device ——Diode

求是 创新

- Diode is always used in low voltage IC ESD protection
- Diode has low trigger voltage (0.7V), some leakage and turn-on resistance
- A kind of Gate diode can be improve its turn-on

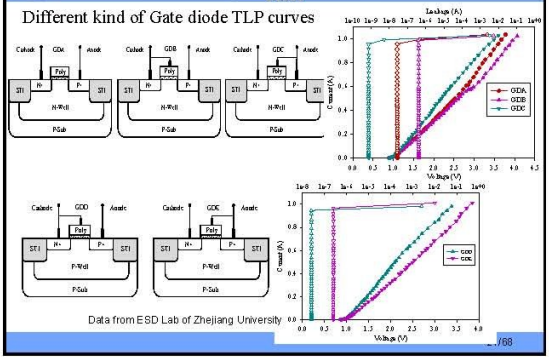


Data from ESD Lab of Zhejiang University

2.1、Basic Device ——Diode

求是 创新

Different kind of Gate diode TLP curves

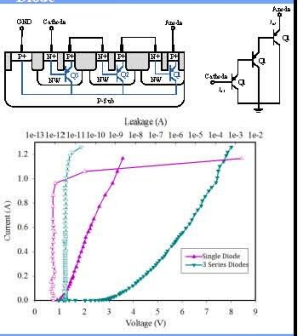


Data from ESD Lab of Zhejiang University

2.1、Basic Device ——Diode

求是 创新

- Diodes in series can meet different voltage demand.
- Owing to Darlington effect, the leakage will increase and voltage increasing will be weaken with the number of Diodes in series.
- It can be improved by retrograde well process

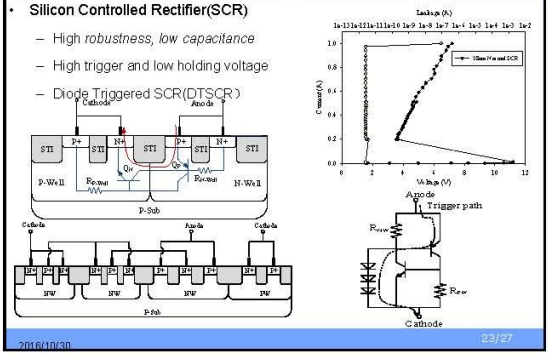


Data from ESD Lab of Zhejiang University

2.1、Basic Device ——SCR

求是 创新

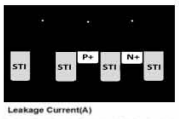
- Silicon Controlled Rectifier(SCR)
  - High *robustness, low capacitance*
  - High trigger and low holding voltage
  - Diode Triggered SCR(DTSCR)

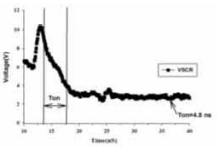


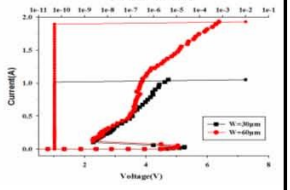
2.1、Basic Device ——SCR

求是 创新

- Vertical SCR，VSCR)
  - Low trigger 5.3V and high holding 2.3V
  - High robustness，33mA/μm
  - turn-on time 4.8ns

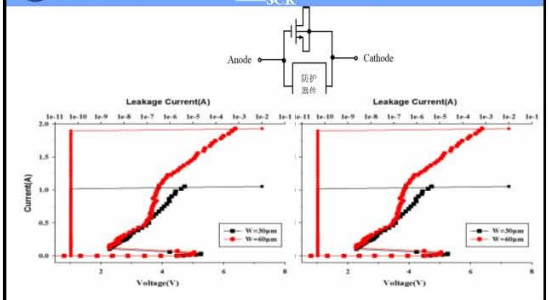






2.1 、Basic Device ——SCR

求是 创新

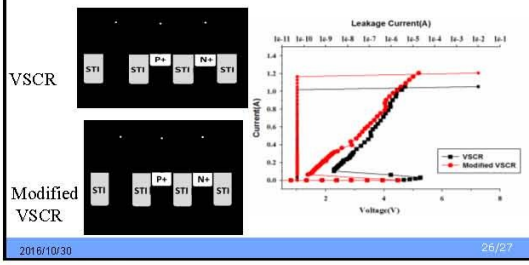


Meet the ESD windows of 40/28nm Core

2.1 、Basic Device ——SCR

求是 创新

- Modified VSCR
  - Low trigger 4.5.3V and high holding 1.4V
  - High robustness，40mA/μm



Outline

求是 创新

1、Basic principle of ESD design

2、Main devices for Nanometer CMOS Process

　2.1 、Basic Devices：

　2.2、Some good candidates

3、Design for Nanometer CMOS circuit

　3.1、Key concerned

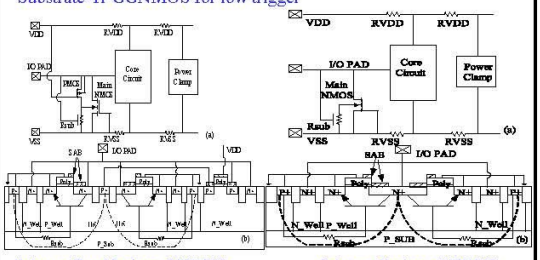
　3.2、System Efficient ESD Design (SEED)

　3.3、New standard JS001/002

Candidates（1）

求是 创新

Substrate-Tr GGNMOS for low trigger



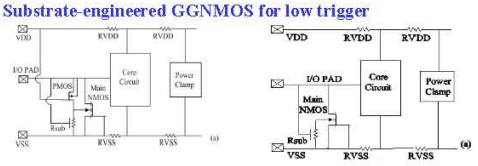
Substrate R and I trigger GGNMOS　　Substrate R trigger GGNMOS

S. Dong, et, Substrate-engineered GGNMOS for low trigger voltage ESD in 65nm CMOS process, Microelectronics Reliability, Volume 51, Issue 12, December 2011, Pages 2124-2128.

Candidates（1）

求是 创新

Substrate-engineered GGNMOS for low trigger



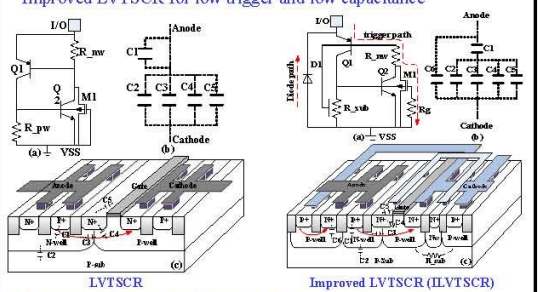
Substrate R and I trigger GGNMOS　　Substrate R trigger GGNMOS

	It2(A)	Vt1(V)	C(pF)	It2/area (mA/um2)
GGNMOS	2.13	6.84	0.652	2.5
Substrate R trigger GGNMOS	2.07	5.3	0.788	2.17
Substrate R and I trigger GGNMOS	2.63	3	0.891	2.33

Candidates（2）

求是 创新

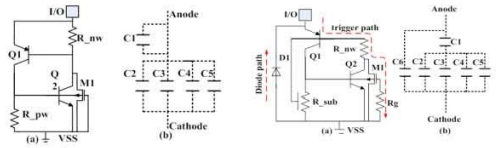
Improved LVTSCR for low trigger and low capacitance



LVTSCR　　Improved LVTSCR (ILVTSCR)

S. Dong, "Improved Low Voltage-Triggered SCR Structure for RF-ESD Protection," Electron Device Letters, IEEE , vol.34, no.8, pp.1050,1052, Aug. 2013.

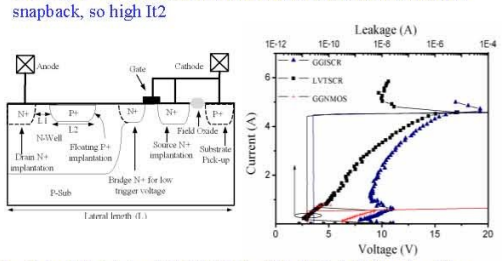
Candidates（2）　求是 创新



Structures	Area /μm²	Vt1 /V	It2 /A	C_{ESD} /fF	I_{leak} /nA
GGNMOS	17*50	7.3	2.13	652	0.9
LVTSCR	6*50	7.5	1.82	130	0.35
DTSCR	12*50	2.5	1.93	96	120
ILVTSCR	9*50	2.2	1.9	50	0.3

Candidates（3）　求是 创新

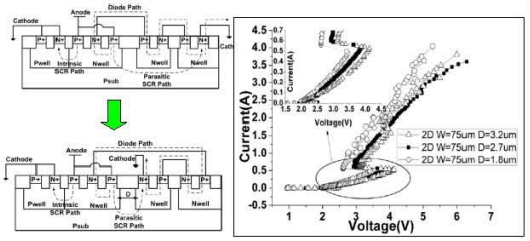
Floating P+ LVTSCR for high holding voltage, which has two snapback, so high It2



S. Dong, "Design and Analysis of an Area-efficient High Holding Voltage ESD Protection Device," IEEE Transaction on Electron Device, 2014,6

Candidates（4）　求是 创新

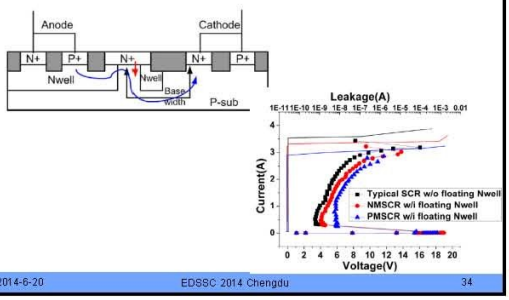
Improved Diode trigger SCR meet 1.8-2V ESD design windows, which also has two snapback



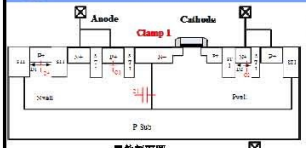
S. Dong, "Minimizing Multiple Triggering Effect in Diode-Triggered Silicon Controlled Rectifier (SCR) for ESD Protection Applications," IEEE Electron Device Lett.,2012,11

Candidates（5）　求是 创新

Improved MLSCR with floating N-well to increasing holding



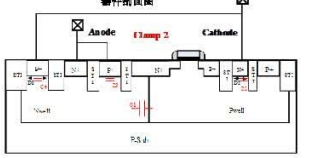
Candidates（6）　求是 创新

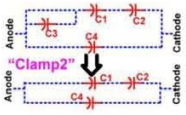


LCSCR，Low Capacitance Silicon Controlled Rectifier。

Clamp 1 traditional device

Clamp 2 is LCSCR

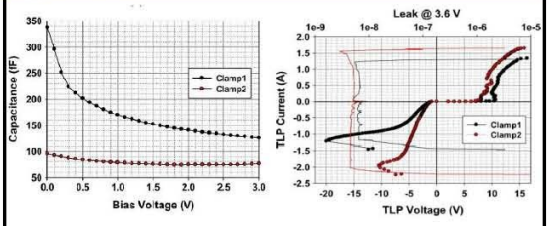




LCSCR capacitance

Q. Cui, J.A. Salcedo et al, "high robustness and low-capacitance silicon-controlled rectifier for high speed io esd protection," IEEE Electron Dev. Let. Vol. 34 NO. 2, 2013, pp. 178-180

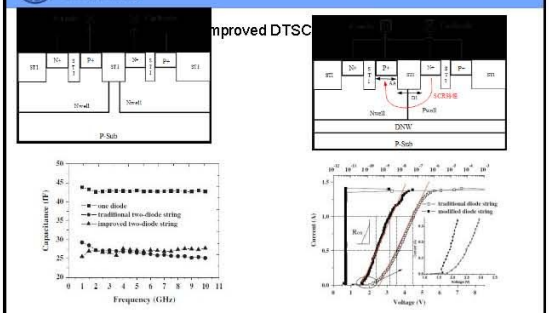
Candidates（6）　求是 创新



Candidates（7）

求是 创新

mproved DTSC



F. Ma, Y. Han, S. Dong, L. Zhong, H. Liang and F. Gao, "Improvement on diode string structure for 65-nm RF ESD protection," Solid-State Electron, Vol. 89, 2013, pp. 142-145

Outline

求是 创新

1、Basic principle of ESD design

2、Main devices for Nanometer CMOS Process

2.1 、Basic Devices：

2.2、Some good candidates

3、Design for Nanometer CMOS circuit

3.1、Key concerned

3.2、System Efficient ESD Design (SEED)

3.3、New standard JS001/002

3.1、Key concerned ——Capacitance

求是 创新

◆High speed interface use there type of signal with low swing, power and noise:

- ◆ PECL (Positive Emitter-Coupled Logic)
- ◆ LVDS (Low-Voltage Differential Signals)
- ◆ CML (Current Mode Logic)。

For example:

VBO use LVDS signal with 655Mbps

USB3 use CMLwith 10Gbps。

■ RC delay Demand Parasitic Capacitance less than 100-30 fF;

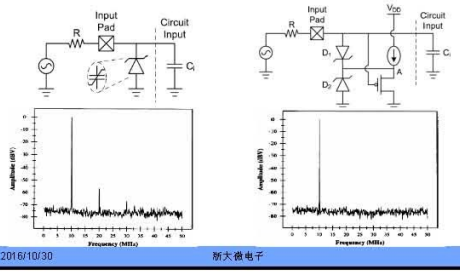
■ Low Parasitic Capacitance will cause high overshoot

Signal Swing

求是 创新

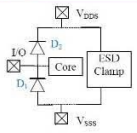
Fro example: 12 bit 20 MS/s A/D converter

■ The zener diode capacitance is changed with signal swing bias

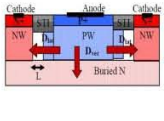


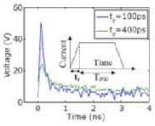
Parasitic Capacitance

求是 创新



I/O ESD protection

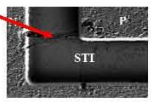




Diode Capacitance include two parts

Failure point

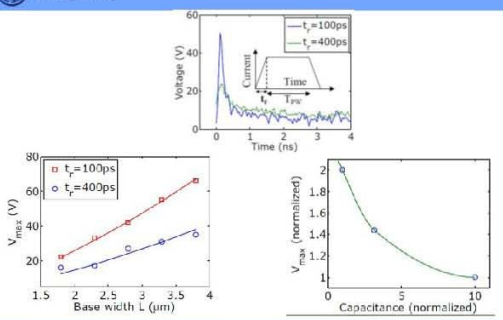
	Rise-time t_r (ns)	I_{TT} (A)
VF-TLP (T_{PR}=10ns)	0.1	5.96
	0.4	7.74
TLP (T_{PR}=100ns)	2	5.49
	10	7.2



F. Farbiz, A. Appaswamy, A.A. Salman and G. Boselli, "Overshoot-induced failures in forward-baised diodes: a new challenge to high-speed ESD design." IRPS, 2013. (Texas Instruments Inc.)

overshoot

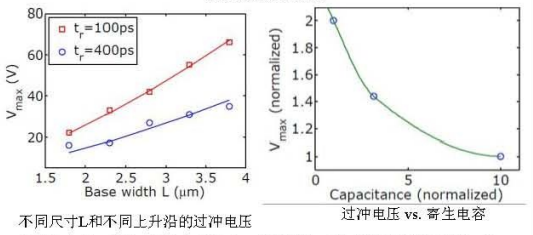
求是 创新



HDMI接口失效案例

求是 创新

器件綜合对比评估



不同尺寸L和不同上升沿的过冲电压　　过冲电压 vs. 寄生电容

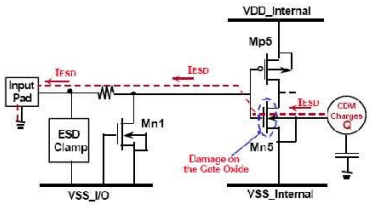
◆器件的参数L越长，过冲电压越高，这个现象对上升沿越快的脉冲越明显

◆越小的寄生电容会导致越高的过程电压，这需要在设计时折中考虑

CDM

求是 创新

ESD Damages Due to CDM ESD Events

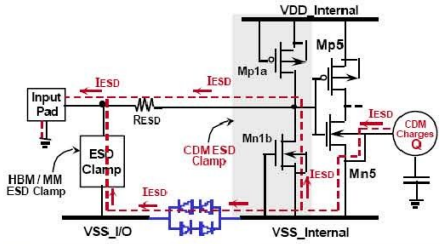


The ESD protection circuit at the input pad can provide effective ESD protection against the HBM and MM ESD events, but it can not provide effective ESD protection against the CDM ESD events.

CDM

求是 创新

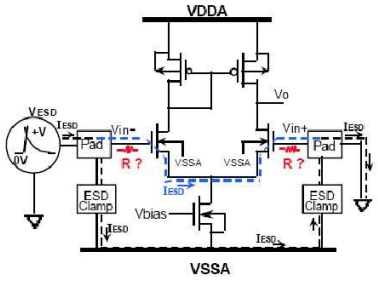
ESD Protection for CDM ESD Events



Different-pair Input

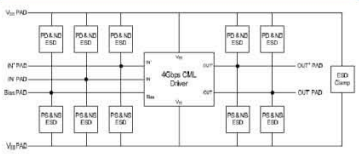
求是 创新

- ESD voltage is across the gate oxides of the different-pair input stage of an Operational Amplifier.

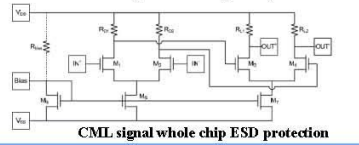


Different-pair Input

求是 创新



CML signal whole chip ESD protection



CML signal whole chip ESD protection

Outline

求是 创新

1、Basic principle of ESD design

2、Main devices for Nanometer CMOS Process

　2.1 、Basic Devices

　2.2、Some good candidates

3、Design for Nanometer CMOS circuit

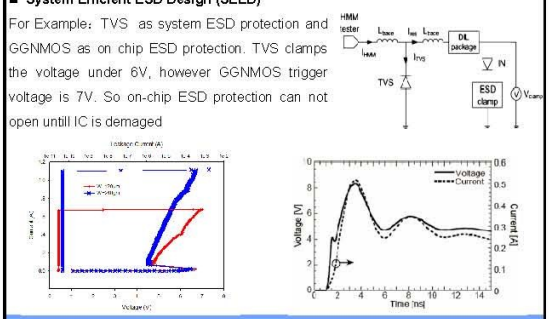
　3.1、Key concerned

　3.2、System Efficient ESD Design (SEED)

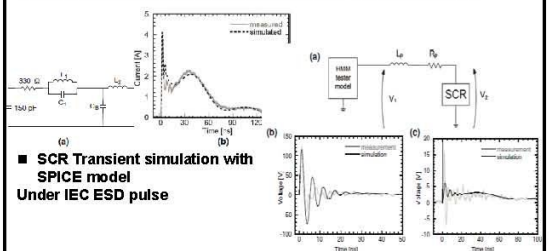
　3.3、New standard JS001/002

■ System Efficient ESD Design (SEED)

For Example：TVS as system ESD protection and GGNMOS as on chip ESD protection. TVS clamps the voltage under 6V, however GGNMOS trigger voltage is 7V. So on-chip ESD protection can not open untill IC is demaged



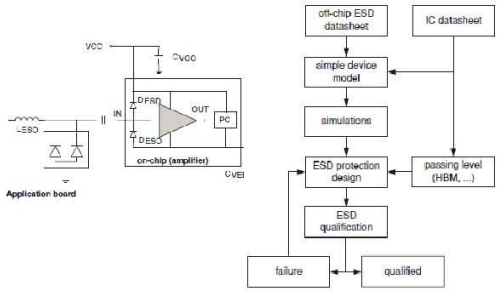
On-chip ESD and TVS Transient simulation with SPICE model to investigate its Transient behaviour and clamp voltage wave form

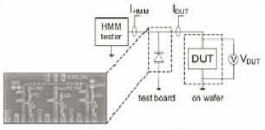


■ SCR Transient simulation with SPICE model Under IEC ESD pulse

■ TVS Transient simulation with SPICE model Under IEC ESD pulse

Basic simulation flow：

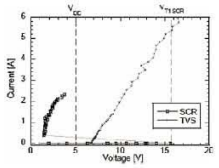




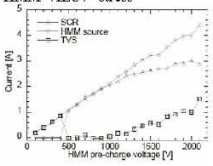
System Efficient ESD Design OF on-board TVS and on-chip SCR ESD protection:

■ SCR can not open under TLP stress

■ TVS open and then SCR open under HMM（IEC） stress



100ns TLP pulse test



30ns HMM pulse test

- There are too many ESD standard from ANSI、ESDA and JEDEC
- JS001-2012及*revised edition* JS001-2014 is proposed in 2012, 2014 respectively
- JS001-2014 include：ANSI/ESDA/JEDEC JS-001-2010 and subsequent versions, ANSI/ESD STM5.1-2007, or JESD22-A114F，ESD ADV1.0, ESD Association's Glossary of Terms1 JESD99, JEDEC Standard - Terms, Definitions, and Letter Symbols for Microelectronic Devices2。

3.3、JS001/002　求是 创新

some new:

1. Failure window

refer our advices, ESD failure window is provided. For example: IC passed 500VHBM, failed 1000VHBM, passed 2000VHBM，then IC ESD failure window is 500V-2000VHBM，and IC ESD level is 500VHBM

2. Uniform Measure parameter

- start voltage is from 70% nominal values, steep volue 50V(100V) before 1KV and 100V(250V, 500V) after 1KV
- spacing interval and times

最短间隔时间和测试次数

	HBM	MM
Mil-883	1秒, 3次	
ESDA	0.3秒, 1次	1秒, 3次
JEDEC	0.1秒, 1次	0.5秒, 1次
AEC	0.5秒, 1次	1秒, 1次

3.3、JS001/002　求是 创新

3. Calibration method and Human Body Model Simulator

- Charge remove circuit
- SOCKET and PCB board calibration
- Standard load calibration

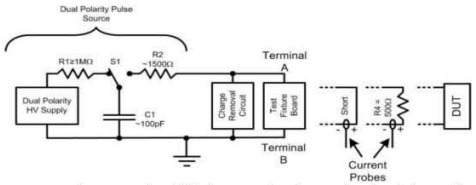


Figure 1: Simplified HBM Simulator Circuit with Loads

3.3、JS001/002　求是 创新

4. Trailing pulse

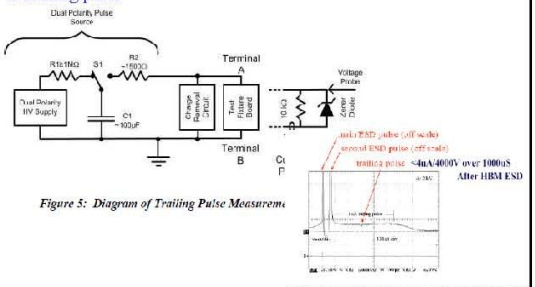


Figure 5: Diagram of Trailing Pulse Measurem

Trailing Pulse (尾波) 示意图，0.13um或更小制程工艺要考虑

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ESD实验室介绍　求是 创新

- 浙江大学ESD实验室是国内第一家专业从事芯片级ESD研发工作的实验室。在国内芯片级ESD领域具有权威地位。具有完善的测试体系和丰富的研究经历，在国际上具有知名度。实验室设备包括：Barth 4002 TLP测试系统、E-GUN+示波器、HP5100B半导体测试仪、Vector DC/RF探针台、ADVAN/HP矢量网络分析仪、SEM/EDA等FA仪器及其他设备，CAD/EDA工作站、服务器及TCAD仿真软件工具TSUPREM-4/MEDICI, ISE-TCAD，SILVACO等。

ESD实验室介绍　求是 创新

主要业绩

- 对外提供ESD设计、失效分析和测试服务36家297次；
- 发表SCI论文56篇，其中TED/EDL论文18篇，出版专著3部，申请发明专利59项授权41项；

合作企业包括：

士兰微电子股份有限公司、矽力杰半导体技术有限公司、杭州立昂电子有限公司 、绍兴恒力特微电子有限公司、清华大学微电子所、北京大学微电子所 、北京昆腾微电子有限公司 、中国科学院上海技术物理研究所、上海力芯集成电路制造有限公司、上海芯奥电子科技有限公司、上海神沃电子有限公司、上海新进半导体制造有限公司、上海先进半导体制造有限公司、灿瑞半导体上海有限公司、复旦微电子、东南大学、南京理工大学、江苏长电科技股份有限公司、江苏东光微电子股份有限公司、苏州晶讯科技股份有限公司 、无锡芯朋微电子有限公司、华润上华科技有限公司、华为、中兴通信、比亚迪、珠海炬力、深南电路有限公司、广州中星半导体公司、长虹公司、电子科技大学、武汉吴宏微电子有限公司、武汉芯景科技有限公司、湘潭大学、香港科技研究院等

ESD实验室介绍　求是 创新

典型应用案例

① 对外提供ESD设计服务21次，ESD失效分析和测试服务36家297次，ESD培训服务6次合计450人次，在业界具有较高知名度；

② 为华虹NEC设计的EEPROM工艺的全芯片ESD技术，广泛应用在目前二代身份证（解决了二代证量产关键难题）、SIM卡、射频卡以及芯片银行卡等产品上，用量超过30亿颗芯片；

③ 为华为设计的35Gbps GaAs高速接口、USB3.1 typeC、VBO、HDMI1.4等芯片的ESD防护，解决了高速接口超低电容ESD防护难题；

④ 微复旦微电子设计的RF IC射频卡ESD，性能超过国际同类产品；

⑤ 设计的超高FOM双向互补电容耦合SCR，被TSMC松江厂用在HVCMOS工艺中，被晶门科技用在液晶显示驱动芯片产品中（其产量占全球21%）；

⑥ 为国产PDP显示屏行驱动芯片（长虹）提供ESD设计，获十一五核高基重大专项“基于自主知识产权的PDP显示控制和驱动芯片 开发与产业化”资助；

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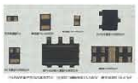
典型应用案例

⑦ 主持中芯国际65~28nm工艺ESD研究，提出多项专利技术，将箝位电压限制在5.6V@8KV内（业界最高指标），解决SMIC的28/45nm工艺量产关键难题；成果受到国际关注，在2014 IEEE EDSMQ会议做keynotes报告，发表TED、EDL论文9篇；

⑧ 提出多通道共核LSCR和通用CMOS工艺的TVS阵列芯片专利技术，受邀APFA2010和2015 IEEE EDSMQ会议Keynotes发言，已授权发明13项，掌握自有知识产权，实现SPW量产，填补国内产品空白；



ESD实验室介绍　求是 创新

典型理论成果

① 提出了JEDEC2003国际标准的漏洞和改进建议（发表在IEEE Trans. on Dev. MR），被美国科技新闻网站誉为“new finding on science”，JS002新标准基于此提出“ESD失效窗口”

② LDMOS 在ESD冲击下雪崩饱和新机理的研究获得英国Electronics Letters期刊作为亮点报道

ESD实验室介绍　求是 创新

典型理论成果

③ 超薄栅氧ESD击穿新现象和新机理发表在JAP和APL上，获得国际关注；集成电路可靠性权威法国里尔大学Steve Arscott教授Rreview中提及本成果是一个有意义的研究；德国飞利浦创新中心Holger Spahr博士正面引用本机理研究了high K介质可靠性；

④ 提出了石墨烯与金属热电失效机理，获得英国皇家学会RSC Advances的“Top 10 most accessed articles in March”。

⑤ 揭示石墨烯超强ESD鲁棒性，因为观点新颖获得英国Electronics Letters首页专访Interview。

求是 创新

Thank You

欢迎联系和交流！
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来萍

来萍（Lai Ping），女，1988 年毕业于复旦大学电子工程系。中国赛宝实验室（工业和信息化部电子第五研究所）研究员级高工，中国赛宝认证中心 ESD 认证项目技术审核专家。广东工业大学和华南理工大学兼职硕士指导教师；IEEE 会员，国际 iNARTE ESD 工程师资质；中国电子学会高级会员；中国静电信息网培训讲师，德国莱茵技术监督服务（广东）有限公司聘用 ESD 讲师。

现在从事半导体器件与集成电路可靠性工作。主要专业领域： 微波器件和电路的可靠性研究，半导体器件和集成电路的抗静电放电（ESD）检测及防护技术研究,以及半导体器件的失效分析和可靠性试验方法研究。

在电子元器件抗 ESD 技术研究方面，自 1994 年起就承担或参加了国家关于电子元器件抗 ESD 水平检测及 ESD 失效机理分析等方面的技术服务及科研项目。在电子元器件 ESD 损伤检测和失效机理分析、制造业静电防护技术等方面有较丰富的知识和经验。

从 2001 年开始，开设了关于电子制造 ESD 防护和检测技术方面的咨询及培训课程，曾给华为电气技术公司、北方电讯、苏州明基、惠州联想、广州日立、欧司朗、深爱半导体、上海蒂森等大型电子企业以及中电集团多个厂所进行了 ESD 技术咨询及企业内部培训，并在深圳、上海、北京、苏州等地举办了多次公开课，参加培训的有全国各地电子企业的有关技术和管理人员。

自 1998 年起，发表关于电子元器件可靠性及静电方面的论文二十多篇，参加了《电子元器件可靠性工程》、《军用电子元器件质量管理与质量控制》、《军用电子元器件失效分析及经典案例》等书的编撰工作。

Lai Ping

Lai Ping, female, graduated from the Department of Electronic Engineering in Fudan University in 1988, senior engineer of China Ceprei Laboratory (the 5th Electronics Research Institute of Ministry of Industry and Information Technology), ESD certification technical audit specialist of China Ceprei Certification Center, part-time Master of guidance teacher both in Guangdong University of Technology and South China University, IEEE member, international iNARTE ESD engineer, senior member of the Chinese Institute of Electronics, trainer of Electrostatic Information Net, ESD lecturer employed by Germany Rhine Technical Supervision Services (Guangdong) Co., Ltd..

Lai engages in the work of the semiconductor devices and integrated circuit reliability. Her main areas of expertise include the reliability of microwave devices and circuits, semiconductor devices and integrated circuits, electrostatic discharge (ESD) detection and protection technology, and research on semiconductor device failure analysis and reliability test methods.

On ESD immunity of electronic components, Lai has undertaken or participated in the technical services and research projects on the level of the country and ESD failure mechanism analysis since 1994. She has a wealth of knowledge and experience in ESD damage detection and failure mechanism analysis of electronic components, and manufacturing electrostatic protection technology.

Lai has opened consulting and training courses on electronics manufacturing ESD protection and testing technology. She has given ESD technical advice and internal training in Huawei Electric Technologies Inc., Northern Telecom, Suzhou BenQ, Huizhou Lenovo, Guangzhou Hitachi, Osram, SI Semiconductors CO., LTD., Shanghai ThyssenKrupp Elevator Company and other large electronics companies since 2001, and held a number of open class for the technical and managerial personnel of the national electronics companies in Shenzhen, Shanghai, Beijing, Suzhou and other places.

Lai has published over 20 papers on the reliability of electronic components and electrostatic since 1998, and participated in the compilation of *Reliability of Electronic Components Engineering*, *Quality Management and Quality Control of Military Electronic Components* and *Military Electronic Components Failure Analysis and Case Studies*.

ESD防护标准与中国电子制造企业的防护工程实际

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引言

- ANSI ESDA S2020是目前中国的电子制造企业开展ESD防护工作时经常参考的行业标准。
- 工程实践中大家对于标准有很多不同的理解，甚至是在一些原则性问题上可以有相距甚远的差异，这无疑将使得部分静电防护工作不能有效地降低静电损伤的风险。
- 本文将基于对众多中国电子制造企业的ESD防护现状调研，针对这些问题进行分析，并提出在标准完善和企业ESD防护改进的相关建议。

Slide 2

内容大纲

- 标准在中国电子制造企业实施中碰到的问题
- 标准完善的建议
- 企业静电防护工程建议

Slide 3

标准在中国实施中碰到的问题

- 基准地的问题
  - 静电放电地与电力地（设备地）之间的关系
  - 静电放电地对地电阻的要求
  - 静电放电地极的施工要求
  - 静电放电地在EPA内的要求

Slide 4

- 基准地的问题

- 静电地桩被填埋于水泥下，并且引出线已经断开

- 地桩深度不够
- 引出线未固定

两块静电桌垫串接

Slide 5

- EPA内防静电地板的选择问题
  - 目前行业比较通行的有三种防静电地板的工程方式：自流坪地板、PVC地板、高架地板。
  - 标准没有把两种地板各有何优劣势，各更适用于哪些场合进行说明。
  - 绝大多数工厂未研读ANSI/ESD STM97.1 、 ANSI/ESD S7.1对防静电地板测试的相关要求.
  - 自流坪地板和PVC地板应该采取何种施工方式，选用何种材料，没有十分明确的说明，特别是对地板材料和施工完成后的地板工程都没有关于其可靠度的测试要求。

Slide 6

CEPREI

- EPA内的防静电地板

地板上仅刷绿漆，非防静电地板

地板下铜箔接地不可靠，或不接地

Slide 7

CEPREI

- 人体静电泄放通道问题
  - 人体的主泄放通道是人体-静电手腕带-静电地，其次是通过防静电鞋泄放，最后还可以通过防静电椅来泄放
  - 不少企业被推荐使用无线手腕带时，并没有考虑它其实根本不符合基本的电路原理
  - 管理人员关注作业人员有没有使用防静电鞋，却不关心地板是否防静电，这也是对这一静电泄放通道包括哪些环节没有认识清楚

Slide 8

CEPREI

- 人体静电泄放通道问题

使用无线静电手环

裸手接触PCBA

站立于木板垫上进行操作

Slide 9

CEPREI

- 包装材料的问题
  - 标准中没有明确何种敏感程度的器件需要使用何种材料进行包装，有过宽的解读空间
  - 实际器件包装存在很多非防静电包装或不当包装
  - 对于可能需要使用自动插件的静电敏感元器件，现在中国基本都是采用非防静电的包装材料，这些元器件应该如何在保证可以上机插件的情况下进行静电保护呢
  - 非敏感器件的易致静电放电包装如何处理的问题。

Slide 10

CEPREI

- 包装材料问题

大量使用非防静电的袋、海绵、盒、箱

使用薄膜包裹烧录器

易致静电的料箱

Slide 11

CEPREI

- 过度使用离子中和的问题
  - 离子中和技术近年来明显存在过度使用的现象，一方面造成了巨大浪费，另一方面由于空气被电离而又引起了ESD风险
  - 某些企业在工程操作层面却过分依赖离子中和技术，而不去做减少静电产生的工作和泄放静电的工作
  - 某些企业，离子中和技术无限扩大地使用到一些完全没有静电发生风险的场合

Slide 12

标准完善的建议

- 静电放电的基准地
  - 给出电力地满足什么样的条件才是可以直接用作静电地
  - 如果电力地不可靠的情况下，给出可操作的电力地改善方法
  - 在电力地无法改善的情况下，应该采取何种方式来建立静电基准地
  - 对于EPA内的静电地线网络，应该给出几种结构供企业选择，以及应该提出主线、支线、终端接线的不同线材要求

Slide 13

- 防静电地板
  - 应该对自流坪地板和PVC地板的用材和工程施工分别提出一些最低规范，比如PVC地板，应该有原始地板的平整度、干燥度，地面铜网所使用铜箔的厚度、铺设密度，导电胶的粘度和电导率，地板材料导电特性、起尘特性、防火特性等。而重点应该关注的是防静电地板的长期使用可靠度。
  - 其次，分别列出自流坪地板和PVC地板的优缺点，并提出建议最好应用于什么场合，以供企业选择

Slide 14

- 人体泄放通道
  - 建议在标准中增加对人体静电泄放通道的系统性描述，最好是用图例的方式将通道的完整回路展现出来，并将最容易出问题的关键点进行重点说明。这样才更有利于工厂工程师理解标准和执行标准

Slide 15

- 包装材料
  - 在已给出不同性质包装材料的介绍的同时，提出哪种包装材料更适合用于哪些场合的建议。这将有利于元器件生产厂家和电子组装厂家合理使用和辨别。
  - 对于没有按要求包装的物料，以及需要拆包装分捡的物料，应该给出需要满足何种条件的包装材料。
  - 对于A/I的静电敏感器件，需要对编带材料的防静电规格进行规范。
  - 对于非敏感元器件的易致静电包装材料，应该在标准中明确定规定，必须在进入EPA前替换成不易产生静电的包装材料或治具

Slide 16

- 离子中和
  - 标准中明确离子中和技术是在其它静电防护措施无法将静电电压控制在期望值以内时才采取的补救措施。
  - 规定至少需要采取哪些防止静电产生措施和静电耗散措施。
  - 特别需要规定离子中和器具（如离子风机等）的维护保养策略，以保证其使用的可靠性和安全性

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企业静电防护工程建议

- 静电放电的基准地
  - 最好是另行埋设一组或多组接地桩，并在任何区域严禁此地桩所引入的地线网络和原有的电力地进行搭接。
  - 地桩对地电阻建议控制在1Ω以内，条件确有限制的，也应该保证在10Ω以内。
  - 地桩的埋设现行有很多做法，但使用多根铜棒，远离其它地下设施，铅焊等应该是大家比较认同的基本做法。
  - EPA室内静电地线网络建议使用三层架构，线材可用铜带或黄绿多股铜芯线

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- 防静电地板
  - 对于一般电子车间，建议使用PVC地板，PVC地板的导电参数稳定性高于自流坪地板。
  - 对于要求不高的老式电子车间，可以使用自流坪，但要保证至少每半年刷一次防静电漆，且对地板的测试频率也应加大到3个月。
  - 工厂最好不使用高架防静电地板。

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- 人体泄放通道
  - 应该禁止使用无线手腕带，并建议使用手腕带报警器，以保证“人体-手腕带-地”的这一最重要的人体静电泄放通道的可靠性。
  - 另外，通过严格的周期性测试，确保防静电地板的导电性能在规定的范围内。通过严格的周期性测试，确保静电鞋和静电椅在规定的范围内。
  - 最后，要保证地线网络和最后接地点稳定可靠。

Slide 20

- 包装材料
  - 在无法控制元器件供应商采取何种包装的情况下，组装企业最好是对其包装材料进行测试，确保其为屏蔽材料或耗散型材料。如果不是，则进行更换。
  - 对于需要拆包装的器件需要同样使用屏蔽材料或耗散型材料进行二次包装。
  - 对于所有易到高静电电压的其它元器件的包装材料，当前最可行的办法就是在其进入EPA前全部换成不产生静电的包装材料或治具。
  - 对于A/I类静电敏感器件，暂时没有很好的解决措施。

Slide 21

- 离子中和
  - 对于EPA内所有工位，应该先尽可能地撤除易致静电的物品，即使不能撤除，也应该确保存放在30cm外的固定位置；另外，尽可能地做好静电泄放工程，确保即使产生静电也能按要求泄放。
  - 在采取上述两种措施后仍然不能将静电电压控制在规定范围内的工位，采取离子中和方法。
  - 同时配备检测离子中和器具的仪器，定期测试，从而管控离子中和器具的可靠性和风险。

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总结

- 对上述在ESD防护工程上的问题，既需要行业标准更多的考虑企业实施的实际情况，也需要理清标准的原本意图，从而使企业在操作层面能做到全面而恰当的防护。
- 希望ESDA可以组织专门力量对中国各类型电子制造企业的静电防护现状进行实地调研，从而制定一套更适用于中国的静电防护行业标准。
- 希望本文能为标准制定者和企业静电防护的技术管理人员提供更为理性的思考。

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Plant-level ESD Standards in China's Electronics Manufacturing Industry

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Objectives

- Summarize the status of ESD control in Chinese electronics manufacturing industry
- Identify the reasons for deficiencies in implementation.
- Give some suggestions for standard suitability and proper implementation.
- Finally, enable the Chinese electronics plants to improve the quality of products.

Slide 2

Presentation topics

- Problems Encountered in the Implementation of Standards in Chinese Electronics Factory
- Recommendation for Standards
- Recommendation for Factory ESD Protection Engineering Project

Slide 3

Current problems in China

- Grounding/bonding Systems
  - The relationship between power equipment grounding and electrostatic grounding;
  - The required limit of impedance for the electrostatic grounding;
  - The construction requirements of the electrostatic grounding;
  - The requirements of electrostatic grounding in the ESD Protected Areas (EPAs).

Slide 4

Current problems in China

- Grounding/bonding Systems

- Rod depth not enough;
- Wire separated from rod

- Rod buried below concrete;
- Wire separated from rod, lost

Improper connection to anti-static mat

Slide 5

Current problems in China

- Anti-static Floors in EPAs
  - The guidance in ANSI/ESD S20.20 as well as ANSI/ESD STM97.1 and ANSI/ESD S7.1 applies to testing of floors and flooring materials.
  - However, the choice of the appropriate construction and materials for all floors is left up to the user.
  - Nonetheless, both ANSI/ESD STM97.1 and ANSI/ESD S7.1 are additional documents that are not available in Chinese, limiting their usefulness inside the Chinese factory.

Slide 6

Current problems in China

- Anti-static Floor in EPAs

Floor severely damaged
Only green paint without copper

Copper was separated from the electrostatic wire

Slide 7

Current problems in China

- Personnel Grounding
  - The requirements for personnel grounding have been confusing in practice when applied in the typical factory in China.
  - Did not recognize that the wireless wrist strap does not conform to basic circuit principles.
  - Focuses on whether employee wear anti-static shoes or not, but may ignore the resistance characteristics of the floor altogether.

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Current problems in China

- Personnel Grounding

Wireless wrist strap

Touching the PCBA without any protection

Standing on a wooden mat

Slide 9

Current problems in China

- Package Materials
  - Very often factories make improper interpretations of what ESD protective packaging requirements are.
  - many non-ESD safe packages and packaging materials used in EPAs of Chinese factories.
  - there is no definite requirement for the packaging of electrostatic sensitive components used during A/I process.
  - How to deal with the non-ESD safe packaging used for non-ESD devices in EPAs.

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Current problems in China

- Package Materials

Hi-static package material for devices

Hi-static package material for burner

Hi-static package box

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Current problems in China

- Overuse of the Ionization System
  - Not only caused added cost, but also can cause a latent ESD risk by air ionizing.
  - factories are too dependent on ionization systems and ignore the work required to reduce generation and discharge of electrostatic charges.
  - In China, some factories expand ionization system usage into areas that have no identified electrostatic risk.

Slide 12

Recommendation for Standards

- Grounding/bonding Systems
  - provide a clear requirement to determine whether the grounding can be directly utilized as the electrostatic grounding.
  - the operational methods should be stipulated to deal with the condition when the power grounding is not reliable.
  - consider ways to establish electrostatic grounding when power grounding can't be improved.
  - give several examples of structures and different requirements for the static ground wire network in the EPA.

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Recommendation for Standards

- Anti-static Floor in EPAs
  - Some minimum specifications that refer to the materials and construction should be put forward for self-leveling floors and PVC floors. Emphasis should be focused on the long-term reliability of the anti-static floor.
  - List the advantages and disadvantages of self-leveling floors and PVC floors respectively, and put forward the proposal for the best applications for enterprises to choose.

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Recommendation for Standards

- Personnel Grounding
  - Increase the systematic description of the human body electrostatic discharge channel in the standard documents.
  - It is best to use illustrations to show the complete circuit and emphasize the key points.

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Recommendation for Standards

- Package Materials
  - Describe the suitable applications for each kind of packing material.
  - Specify the requirements for packaging materials used for components with no packaging materials and for components that require repackaging.
  - Specify requirements for the packaging materials of ESD devices used in automated insertion.
  - Specify that the non-ESD safe packaging used for non-ESD devices must be replaced by ESD safe packaging materials or fixture before entering the EPAs.

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Recommendation for Standards

- Overuse of the Ionization System
  - Demonstrate that ionization systems are only remedial measures used in the condition that field electrostatic protective measures cannot control the electrostatic voltage within the target value.
  - List the measures that should be taken to reduce generation and dissipation of electrostatic charge before adopting and ionization system.
  - Maintenance strategies to ensure the reliability and safety of ionizers also should also be specified.

Slide 17

Recommendation for Factory

- Grounding/bonding Systems
  - Give up the power grounding provided by the power company, and prepare new grounding for both electrostatic and power yourself.
  - Embedding multiple copper bars combined with lead welding away from other underground facilities.
  - Three-layer architecture can be used for the wire network of static grounds in an EPA.

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Recommendation for Factory

- Anti-static Floor in EPAs
  - It is recommended that the general electronic factory use a conductive or dissipative PVC floor.
  - Self-leveling floor can be selected for some old electronics workshop with low ESD protection requirements, but shall be reapplied at least every six months while increasing the test frequency to 3 months.
  - It is generally too expensive to use elevated ESD protective floors for the electronic factory.

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Recommendation for Factory

- Personnel Grounding
  - Wireless wrist strap should be expressly forbidden, and constant wrist strap monitors should be recommended.
  - Verify the conductivity characteristics of anti-static floor, ESD footwear and static protective seating within the prescribed scope through strict periodic testing.
  - Ensure that the ground wire network and the terminal are stable and reliable.

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Recommendation for Factory

- Package Materials
  - Evaluate the ESD protection characteristics of the packaging materials to ensure that they are shielding materials or dissipative materials.
  - Proper shielding materials and dissipative materials should also be used for the components that need be repackaged.
  - For the non-ESD safe packaging used for non-ESD devices, the best practice is to replace these with ESD safe packaging materials or fixtures before entering the EPA.

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Recommendation for Factory

- Overuse of the Ionization System
  - Proper training is needed to address the overuse and misuse of ionization systems.
  - Insulators shall be kept a minimum of 30 cm from all ESD sensitive devices.
  - Ionization systems can and should be adopted if the above measures cannot control the electrostatic voltage within the target value.
  - Periodic verification testing of ionizers also should be performed.

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Conclusions

- Solving the issues discussed above and achieving proper ESD protection will require the standards or handbooks to consider the actual situation of enterprises more carefully.
- By providing the ESD Association with better information about current ESD practices in Chinese electronics manufacturing enterprises, it is expected that more suitable electrostatic protection standard documents will be developed.

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刘民

刘民，1969 年出生，研究员，博导。现任中国空间技术研究院北京东方计量测试研究所计量总师，研发中心主任。国际无线电科学联盟 URSI 中国委员会电磁计量分委会主席。《电子测量与仪器学报》《计测技术》编委委员。宇航学会计量测试分会委员。中国空间技术研究院计量与标定技术专业学术带头人。iNarte 国际认证 ESD 工程师。

刘总师从事电磁学测量和计量前沿的研究工作，在阻抗、电功率、静电、地线等方面造诣精深，发表相关论文 40 多篇，起草国家军用标准、航天行业标准、中国空间技术研究院标准。获 4 项发明专利，其中一项获第十二届中国专利奖优秀奖。在静电防护方面开展多年的 ESD 培训、测试以及静电防护管理体系认证咨询工作，被中国空间技术研究院静电防护管理体系认证中心聘为 ESD 高级审核员。

Liu Min

Liu Min, born in 1969, Professor, doctoral supervisor, leader of science and technology in China Aerospace Science and Technolgy Corporation (CASC), Chairman of electromagnetic measurement subcommittee of China committee of Union of Radio Science International (URSI), iNarte international ESD certification engineer. He is the chief engineer of Beijing Orient Institute of Measurement and Test (BOIMT) and the secretary-general of Beijing Electronic Instrument Industry Association (BEIIA).

Liu engages in research on electric-magnetic measurement and metrology frontiers, and proficient in Space Metrology, and ESD protection. He has published over 50 papers, 6 invention patents. In the field of ESD protection, he has drafted many of national standard, industry standard, and manufacturer's standard, He has been working on ESD training, testing and advising for ESD control management system, and working in Electrostatic Discharge Certification (ESDC) as an ESD senior auditor of ESDC in CAST.

国家标准GB/T 32304
《航天电子产品静电防护要求》
解读与应用

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北京电子仪器行业协会
二零一六年十一月

目　录

背景

背景

航天电子产品中使用了大量静电敏感器件，航天电子产品从设计、研制、生产、测试、到在轨工作的各个环节，均有可能因静电放电造成电子器件的损伤甚至失效，会给航天任务带来严重隐患。

为了杜绝静电放电造成的航天器质量事故，我国对航天电子产品的静电防护提出了明确的管理和技术要求，并在航天电子产品生产单位运行实施，得到了成功验证和应用。

GB/T 32304-2015《航天电子产品静电防护要求》将对航天电子产品全寿命周期的静电防护起到有效指导和控制作用。

背景

1、国内静电标准现状

① GJB 1649-1993《电子产品防静电放电控制大纲》

从美军标MIL-STD 1686A-1988《用于电气和电子元件、组件与设备（电动引爆装置除外）防护的静电放电控制大纲》转化过来的；MIL-STD 1686A于1992年被MIL-STD 1686B所代替，MIL-STD 1686B于1995年被MIL-STD 1686C所代替。

② GJB/Z 105-1998《电子产品防静电放电控制手册》

配套GJB 1649，转化自MIL-HDBK 263A-1991《用于电气和电子元件、组件与设备（电动引爆装置除外）防护的静电放电控制手册》；263A于1994年被263B所代替。

背景

1、国内静电标准现状

③ GJB 3007A-2009《防静电工作区技术要求》

对防静电工作区提出了详细的技术要求，但未对静电防护的管理方面提出全面要求。

④ SJ/T 10630-1995《电子元器件制造防静电技术要求》和SJ/T 10533-1994《电子设备制造防静电技术要求》

制定时间较早，偏重于技术要求，未对防静电的管理和技术要求做出全面的规定，不能完全满足航天电子产品防静电的需求。

背景

1、国内静电标准现状

⑤ QJ 1693-1989《电子元器件防静电要求》（后被QJ2245代替）、QJ2245-1992《电子仪器和设备防静电要求》

制定时间早，关注技术要求多，对静电防护的管理内容偏少，而且很多当时的静电技术要求已不适用于现在的工作。

⑥ 中国空间技术研究院（CAST）院标Q/W 1300~1303-2010《静电防护管理体系系列标准》和中国航天科技集团公司标准Q/QJA 118~123-2013《航天电子产品静电防护管理体系系列标准》

国内首套电子产品静电防护管理体系化标准，并在航天电子产品领域推广实施，目前近30家国防军工单位通过体系认证，超过80家军工企业、中科院、总参谋部等单位正在开展体系建设工作。

背景

2、国外静电标准现状

① 美国ESD控制通用标准

2007年，ESDA对S20.20:1999进行了全面的修订，颁布了2007修订版，使得该标准更加简洁，通用性更强。2014年8月该标准2014新版发布，增加并修改了部分技术要求，强化了产品认证等管理要求。

② NASA航天ESD控制标准

配套NASA于2002年2月宣布，接受S20.20:1999作为NASA静电防护标准，同时废止NASA的ESD标准NASA-STD-8739.7:1997。2007版S20.20颁布后，NASA立即宣布实施新版S20.20。

背景

2、国外静电标准现状

③ IEC和欧洲ESD控制通用标准

2007年，在吸纳ANSI标准基础上，IEC 61340-5-1颁布了最新修订版，在结构、内容和技术要求上与ANSI/ESD S20.20:2007完全协调一致。并且配套标准新版IEC TR61340-5-2:2007用户指南同时颁布，作为IEC的技术报告，为IEC 61340-5-1:2007的实施提供指南。

国际静电防护标准基本以ANSI/ESD 标准为导向，形成了较为系统完成的控制方案、测试方法等标准体系，代表了国际静电防护水平前沿，是国际范围应用最为广泛的静电防护标准，是国际其他组织、国家（包括中国）参考编制标准的主要依据。

背景

3、国标编制基本情况

- 标准编制基础

  Q/W 1300-2010《静电防护体系管理要求》、Q/QJA 118-2013《航天电子产品静电防护管理体系要求》、Q/QJA 119-2013《航天电子产品静电防护技术要求》，已经有5年的实战经验。

- 国内标准继承性

  参考了GJB 1649内容，兼顾考虑了与GJB 继承性和一致性。

- 采用国际标准情况

  与ANSI/ESD S20.20:2014 和 IEC 61340-5-1:2007 保持一致，跟踪国际静电防护管理和技术的最新要求。

  中国是IEC组织的成员，曾考虑过等同转化IEC标准，但鉴于中国航天的严格要求，在IEC基础上提高了管理和技术要求。

GB/T 32304标准解读

GB/T 32304标准解读

1、范围

- GB/T 32304 规定了航天电子产品静电防护的一般要求以及策划、培训、防静电工作区、包装、标识、采购和外包、监视和测量、审核、管理评审和改进等详细技术和管理要求。
- GB/T 32304 适用于航天静电放电敏感电子产品的采购、生产、检验、测试、失效分析、包装、标识、维修、储存、分发和运输等科研、生产活动，也可作为对组织静电防护管理体系进行评价或审核的依据。

GB/T 32304标准解读

3、静电防护技术要求

- 组织
- 文件
- 静电防护目标
- 识别
- 培训
- 防静电工作区—总则、划分、配置、接地/等电位连接系统、人员接地、工具和设备接地、防静电工作区管理等

12个要素

- 包装
- 标识
- 采购和外包
- 监视和测量
- 审核
- 管理评审
- 改进

GB/T 32304标准解读

3、静电防护技术要求

- 防静电工作区—接地/等电位连接系统

表 1　接地/等电位连接系统要求

技术要求	实施方法	要求的阻值
接地/等电位连接系统	保护接地线	符合电源供电的安全要求
	功能地	符合电源供电的安全要求
	等电位连接	$<1\times10^{3}\Omega$

*防静电用品、设备、设施对其公共连接点的最大电阻值应小于 $1\times10^{9}\Omega$。对于静电防护来说，此电阻没有最小值，应根据相关的安全要求，确定安全防护所需的最小电阻值。

- 防静电工作区—人员接地
  - 工位操作时，应佩戴腕带，接地电阻满足$1\times10^{6}\Omega\sim3.5\times10^{7}\Omega$。
  - 通过地板—鞋束系统接地，接地电阻满足$1\times10^{5}\Omega\sim1\times10^{9}\Omega$，且人体电压小于100V。
  - 利用防静电服实现人员接地时，包括人员、防静电服和接地线在内的对接地点的总电阻应小于$3.5\times10^{7}\Omega$。

GB/T 32304标准解读

3、静电防护技术要求

- 防静电工作区—工具和设备接地
  - 防静电电烙铁、吸锡器、有源测线器（热测器）等使用交流电的工具应可靠接地，工具的操作面(或与ESDS电子产品接触的表面)对接地点的电阻应小于10Ω。
  - 不使用交流电的工具，包括手动工具(如扁嘴钳、剪线钳、镊子、夹具等)、气动工具和电池动力工具等，应通过防静电工作台面或使用工具的人员实现接地。当固定在防静电工作台面或被操作人员使用时，工具的操作面(或与ESDS电子产品接触的表面)对接地点的电阻应小于$1\times10^{9}\Omega$。
  - EPA内的设备应可靠接地，与ESDS电子产品接触的表面对接地点的电阻应小于$1\times10^{9}\Omega$。

GB/T 32304标准解读

3、静电防护技术要求

- EPA分类要求
  - I类：直接或间接接触、处置ESDS元器件、组件(电路板等)的区域。如库房，元器件筛选、老化和测试，电装，电路板调试、维修、检验和清洗，单机调试，与ESDS单机直接相连的电缆所处区域等。
  - II类：处置ESDS单机设备(ESDS元器件、组件已经做了一定的防护)的区域。如单机环境试验，单机老化，有静电敏感要求的产品部装、总装，单机库房等。
- EPA配置要求

不同类型的EPA有不同的配置方案。

表 2　EPA 配置要求

序号	要求项目	I 类 EPA	II 类 EPA	选择条件
1	标识	●	●	–
2	防静电地面	●	●	–
3	防静电工作台	●	●	–
4	防静电储存架/柜	●	●	–
5	防静电椅/凳	●	○	–
6	防静电移动设备	▲	○	在 EPA 内转运未经防护的 ESDS 电子产品时必选
7	静电防护包装	●	○	–
8	防静电服、帽	●	●	–
9	防静电鞋	●	●	–
10	防静电鞋套、脚跟带	●	●	–
11	防静电手套/指套	▲	▲	有洁净度要求时必选
12	防静电腕带	●	●	–
13	防静电工具	●	○	–
14	防静电离子风机	▲	○	处置绝缘物品和进行不便于接地的操作时必选
15	防静电涂料、降阻剂	○	○	–
16	温湿度监测仪表	●	●	–
17	人体静电综合测试仪	●	●	–
18	腕带测试仪	●	●	–
19	静电连续监测仪	▲	—	电装车间必选
20	电烙铁测试仪	▲	—	电装车间必选
21	非接触式静电电压表	▲	○	至少有一台用于日常监测

注：●表示必选；—表示不要求；▲表示条件必选；○表示可选(根据各单位具体情况考虑，如器件静电敏感电压、操作人员多少等)。

GB/T 32304标准解读

3、静电防护技术要求

- EPA内防静电用品、设备、设施的技术要求
  - 本技术要求限值适合于对静电敏感度在人体模型HBM 100 V及以上、带电器件模型CDM 200 V及以上和孤立导体 35 V及以上的ESDS产品的静电防护技术要求。
  - 如果处置静电敏感度更高的ESDS产品，需要增加控制项目或调整限值。
  - 当提供了特殊处置过程和处置项目的设计文件，并提供验证报告后，仍视为符合本标准要求。

表 3 - EPA 内防静电用品、设备、设施的技术要求

名称	产品认证要求	监视和测量要求（符合性验证）
地面（地板、地垫）	点对点电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$	点对点电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$
	点对接地点电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$	点对地电阻 $1\times10^6\Omega$～$1\times10^9\Omega$
	人体走动电压<100 V	—
工作台（台面、台垫）	点对点电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$	点对点电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$
	点对接地点电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$	点对地电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$
	充电孤立导体接触分离后残余电压<200 V	—
储存架柜（储存未经防护的 ESDS 产品）	点对点电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$	点对点电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$
	点对接地点电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$	点对地电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$
椅/凳	点对接地点电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$	点对地电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$
防静电移动设备(如小车、梯子等)	点对点电阻<$1\times10^9\,\Omega$	表面对地电阻<$1\times10^9\Omega$
	点对接地点电阻<$1\times10^9\,\Omega$	
静电防护包装	与 ESDS 接触的表面点对点电阻 $1\times10^6\,\Omega$～$1\times10^{15}\,\Omega$	内、外表面点对点电阻<$1\times10^{15}\,\Omega$
	防静电屏蔽包装 内感应能量<50 nJ	
防静电服、帽	点对点电阻 $1\times10^6\,\Omega$～$1\times10^{12}\,\Omega$	点对点电阻 $1\times10^6\,\Omega$～$1\times10^{12}\,\Omega$
可接地防静电服	点对接地点电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$	点对地电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$
可接地防静电服系统	$1\times10^6\,\Omega$～$3.5\times10^7\,\Omega$	$1\times10^6\,\Omega$～$3.5\times10^7\,\Omega$

名称	产品认证要求	监视和测量要求（符合性验证）
防静电鞋	鞋底电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$	鞋底电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$
防静电鞋套、脚跟带	鞋底导电带电阻 $1\times10^6\Omega$～$1\times10^9\Omega$	鞋底导电带电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$
防静电手套、指套	内、外表面点对点电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$	内、外表面点对点电阻 $1\times10^6\,\Omega$～$1\times10^9\,\Omega$
防静电腕带	腕带线缆端对端电阻 $(0.8\sim1.2)\times10^6\,\Omega$	腕带线缆端对端电阻 $(0.8\sim1.2)\times10^6\Omega$
	腕带套内表面对电缆扣电阻 <$1\times10^6\,\Omega$	腕带套内表面对电缆扣电阻 <$1\times10^6\,\Omega$
	腕带套外表面对地电阻>$1\times10^7\,\Omega$	腕带套外表面对地电阻>$1\times10^7\,\Omega$
腕带插孔	腕带插孔对接地点电阻<2 Ω	腕带插孔对地电阻<2 Ω
	腕带插头与插孔的拔出力>1.5 N	腕带插头与插孔的拔出力>1.5 N
电烙铁、吸锡器、热剥器、拆焊等手持电装工具	与 ESDS 电子产品的接触面对地电阻<2 Ω	与 ESDS 电子产品的接触面、对地电阻<10 Ω
	与 ESDS 电子产品的接触面电压<20 mV	
	与 ESDS 电子产品的接触面泄漏电流<10 mA	
镊子、毛刷、钳子、夹具等手持工具	与 ESDS 电子产品的接触面对可接地邻位电阻<$1\times10^6\,\Omega$	与 ESDS 电子产品的接触面、对地电阻<$1\times10^6\,\Omega$
自动取放、自动电装、环境试验等设备	—	与 ESDS 电子产品的接触面、对地电阻<$1\times10^6\,\Omega$
离子风机	静电衰变时间、 不大于 20 s(从±1000 V 衰变到±100 V)	静电衰变时间、 不大于 20 s(从±1000 V 衰变到±100 V)
	残余电压、 不大于±35 V	残余电压、 不大于±35 V
静电连续监测仪	由用户或产品规范规定	由用户或产品规范规定

GB/T 32304标准解读

3、静电防护技术要求

- EPA内防静电用品、设备、设施检测周期
  - **连续：温度、相对湿度。**
  - **每天：静电防护屏蔽包装外观完整性、佩戴腕带情况下人体对地连接、电烙铁等电装工具接地电阻。**
  - **每月：防静电地面（地板、地垫）接地连接、防静电工作台（台面、台垫）接地连接、公共接地点对电源保护地电阻等。**
  - **半年：防静电椅/凳对地电阻、防静电移动设备(手推车、梯子、搬运车、吊车等)表面对地电阻、腕带插孔、镊子等手持工具接地电阻等。**
  - **一年：防静电地面（地板、地垫）点对点/点对地电阻、防静电储存架/柜点对点/点对地电阻、防静电椅/凳对地电阻、人体静电综合测试仪/腕带测试仪/电烙铁测试仪/静电连续监测仪等技术性能等。**

GB/T 32304标准解读

表 A.1 - EPA 内防静电用品、设备、设施检测周期

项目要求		检测周期				
		连续	每天/次	每月	半年	一年
防静电地面（地板、地垫）	接地连接	–	–	●	–	–
	点对点、点对地电阻	–	–	–	–	●
防静电工作台（台面、台垫）	接地连接	–	–	●	–	–
	点对点、点对地电阻	–	–	–	–	●
防静电储存架/柜点对点、点对地电阻		–	–	–	–	●
防静电椅/凳对地电阻		–	–	–	●	–
防静电移动设备(手推车、梯子、搬运车、吊车等)表面对地电阻		–	–	–	●	–
周转容器等静电防护包装表面点对点电阻和静电放电屏蔽性能		–	–	–	–	○
静电防护屏蔽包装外观完整性		–	●	–	–	–
佩戴腕带情况下人体对地连接		–	●	–	–	–
腕带插孔		–	–	–	●	–
防静电服	个人着装情况	–	●	–	–	–
	点对点电阻或对地电阻	–	–	○	–	–
穿着防静电鞋、鞋套情况下人体对地连接		–	●	–	–	–
电烙铁等电装工具接地电阻		–	●	–	–	●
镊子等手持工具接地电阻		–	–	–	●	–

GB/T 32304标准解读

自动取放、自动电装、环境试验等设备接地电阻		–	–	–	●	–
离子风机技术性能		–	–	–	–	●
静电接地系统	连续性、完整性	–	–	●	–	–
	公共接地点对电源保护地电阻	–	–	●	–	–
	交流设备导体阻抗	–	–	–	–	●
	专用地线接地电阻	–	–	–	–	●
人体静电综合测试仪、腕带测试仪、电烙铁测试仪等技术性能		–	–	–	–	●
静电连续监测仪	工作状况	–	●	–	–	–
	技术性能	–	–	–	–	●
非接触式静电电压表技术性能		–	–	–	–	●
环境温度、相对湿度		●a	–	–	–	–

注：●表示必选，–表示不要求，○表示批次性抽查。应根据防静电用品、设备、设施的使用方式、条件、频度和年限等适当缩短检测周期。

a 需要某种形式的检测标识，如标签、标牌或记录表格等。

b EPA 接地电阻(接地体与大地间的电阻)应每年检测一次。

c EPA 温度、相对湿度没有条件实现连续记录的，可每日定时记录不少于两次。

标准使用说明

标准使用说明

1、标准使用范围

- GB/T 32304 属于中国航天领域国家标准。
- GB/T 32304 自 2016 年 7 月 1 日实施。
- 提出单位：中国航天科技集团公司。
- 归口组织：全国宇航技术及其应用标准化技术委员会（SAC/TC 425）
- 起草单位：北京东方计量测试研究所、西安空间无线电技术研究所。

中国航天科技集团公司五院五一四所（航天514所）

静电防护产品认证

中国航天科技集团公司五院五一四所
中国航天 No.514 Institute of China Academy of Space Technology of CASC

标准使用说明

3、静电防护产品认证

- 认证类型
  自愿性产品认证
- 认证产品
  静电防护产品
- 认证模式
  型式试验+获证后监督
- 颁发机构
  国家认监委，2016年3月8日

中国航天科技集团公司五院五一四所
中国航天 No.514 Institute of China Academy of Space Technology of CASC

标准使用说明

3、静电防护产品认证

- 认证指定机构：北京东方计量测试研究所（航天514所）

国家航天器研制计量测试中心（筹建）	国家静电防护产品质量监督检验中心（筹建）	国家认监委授
	国家静电防护产品认证机构	国家认监委授
	国家航天器研制计量测试中心（筹建）	国家质检总局授
静电防护管理体系认证中心	国防科技工业电学一级计量站	科工局授
	工业（静电防护）产品质量控制和技术评价实验室	工信部授
	道路运输车辆卫星定位系统平台和车载终端检测机构	交通部授
	北京危险品车载运输监控设备检测检验中心	安监总局授
静电防护 工业和信息化部	中国卫星导航定位设备检测（北京）中心	中定防授
	中国航天科技集团公司静电防护技术中心	集团公司授
	五院静电防护管理体系认证中心	五院授

中国航天科技集团公司五院五一四所
中国航天 No.514 Institute of China Academy of Space Technology of CASC

标准使用说明

3、静电防护产品认证

- 认证产品（产品检测标准）
  - 防静电服
    - GB 12014-2009《防静电服》
  - 防静电工作帽
    - GB/T 31421-2015《防静电工作帽》
  - 防静电手套
    - GB/T 22845-2009《防静电手套》
  - 防静电鞋（导电鞋）
    - GB 21146-2007《个体防护装备 职业鞋》
  - 防静电周转容器
    - SJ/T 11277-2002《防静电周转容器通用规范》

→ 防静电产品生产企业

中国航天科技集团公司五院五一四所
中国航天 No.514 Institute of China Academy of Space Technology of CASC

标准使用说明

3、静电防护产品认证

- 认证产品（产品检测标准）
  - 防静电活动地板
    - SJ/T 10796-2001《防静电活动地板通用规范》
  - 防静电贴面板
    - SJ/T 11236-2001《防静电贴面板通用规范》
  - 防静电地坪涂料
    - SJ/T 11294-2003《防静电地坪涂料通用规范》
  - 防静电陶瓷砖
    - GB 26539-2011《防静电陶瓷砖》
  - 集成电路防静电包装管
    - SJ/T 10147-91《集成电路防静电包装管》
  - …… ……

→ 防静电产品生产企业

中国航天科技集团公司五院五一四所
中国航天 No.514 Institute of China Academy of Space Technology of CASC

标准使用说明

3、静电防护产品认证

- 静电防护产品全性能检测（国检中心）
  - 电性能（静电电压、电阻、衰减时间、能量等）

标准使用说明

3、静电防护产品认证

- 静电防护产品全性能检测（国检中心）
  - 机械/物理性能（强度、耐折、耐磨、耐冲击、老化等）

标准使用说明

3、静电防护产品认证

- 静电防护产品全性能检测（国检中心）
  - 化学性能（pH、甲醛含量、倒氮燃料等）

标准使用说明

3、静电防护产品认证

- 认证结果采信范围
  - 中国空间技术研究院，及其外协单位
    - 五院单位以及科工集团、中电集团、中科院、总参谋部等单位
  - 中国航天科技集团公司
    - 一院、四院、六院、七院、八院、九院、十一院等
  - 国家电子工业静电防护产品使用单位
- 产品认证推广进度
  - 率先在航天领域形成产品认证准入制度，设定产品质量门槛；
  - 后续在国家标准广泛采纳使用过程中，逐步在国防军工系统实施认证；
  - 最后在国家电子工业领域，形成静电防护产品质量认证普遍意识。

谢谢！

Interpretation and Application about National Standard GB/T 32304 *Electrostatic discharge protection requirements for aerospace electronic products*

Lecturer : Liu Min
Beijing Orient Institute of Measurement and Test (No. 514)
Beijing Electronic Instrument Industry Association
November 2016

中国航天科技集团公司五院五一四所
中国航天 No. 514 Institute of China Academy of Space Technology of CASC

Table of Contents

中国航天科技集团公司五院五一四所
中国航天 No. 514 Institute of China Academy of Space Technology of CASC

Background

中国航天科技集团公司五院五一四所
中国航天 No. 514 Institute of China Academy of Space Technology of CASC

Background

Since the aerospace electronic products apply **a large number of static sensitive devices**, they are likely to be damaged or invalid due to ESD in the design, research, manufacturing, production, test and on-orbit working phases. The space mission will be faced with serious hidden dangers.

In order to completely eradicate spacecraft quality accidents caused by ESD, China has put forward clear **management and technical** requirements for ESD protection of aerospace electronic products, and implements them in the aerospace electronic product manufacturer. The verification and application are realized successfully.

GB/T 32304-2015 *Electrostatic discharge protection requirements for aerospace electronic products* will provide guidance for ESD protection of aerospace electronic products(life cycle).

中国航天科技集团公司五院五一四所
中国航天 No. 514 Institute of China Academy of Space Technology of CASC

Background

1. Status quo of domestic static standards

① GJB 1649-1993 *Anti-static Discharge Control Outline for Electronic Products*

It is converted from American Standard MIL-STD 1686A-1988 ESD *Control Outline Used for Electric and Electronic Elements, Components and Equipment (Except for Electric Detonator)*; MIL-STD 1686A was replaced by MIL-STD 1686B in 1992, and MIL-STD 1686B was replaced by MIL-STD 1686C in 1995.

- GJB/Z 105-1998 *Anti-static Discharge Control Manual for Electronic Products*

The attached GJB 1649 is converted from MIL-HDBK 263A-1991 *ESD Control Manual Used for Electric and Electronic Elements, Components and Equipment (Except for Electric Detonator)*; 263A was replaced by 263B in 1994.

中国航天科技集团公司五院五一四所
中国航天 No. 514 Institute of China Academy of Space Technology of CASC

Background

1. Status quo of domestic static standards

② GJB 3007A-2009 *Technical Requirements of Anti-static Working Area*

It has put forward detailed technical requirements for EPA, but fails to propose comprehensive requirements in the aspect of ESD protectionmanagement.

- SJ/T 10630-1995 *Anti-static Technical Requirements about Electronic Components Manufacturing* and SJ/T 10533-1994 *Anti-static Technical Requirements about Electronic Equipment Manufacturing*.

Considering that the earlier standards lay emphasis on the technical requirements and fail to put forward comprehensive requirements for anti-static management and technical requirements, these standards are unable to completely satisfy anti-static requirements of aerospace electronic products.

中国航天科技集团公司五院五一四所
中国航天 No. 514 Institute of China Academy of Space Technology of CASC

Background

1. Status quo of domestic static standards

⑮ QJ 1693-1989 *Anti-static Requirements about Electronic Components* (replaced by QJ2245 later) and QJ 2245-1992 *Anti-static Requirements of Electronic Instrument and Equipment*

Due to the earlier formulation time, the foregoing standards lay more emphasis on technical requirements and fail to cover ESD protectionmanagement completely, and the static technical requirements at that time are unsuitable for the current job.

- Q/W 1300~1303-2010 *ESD protectionManagement System Standards* (the standard of China Academy of Space Technology) and Q/QJA 118~123-2013 *ESD protectionManagement System Standards of Aerospace Electronic Products* (the standard of China Aerospace Science and Technology Corporation)

It is the first set of ESD protection management system standards about electronic products domestically, which have been promoted and implemented in the aerospace electronic products field. Until now, there are nearly 30 national defense industry units have passed through the system certification, and more than 80 military industrial enterprises, China Academy of Sciences, Headquarters of the General Staff and other units are carrying out system construction.

Background

2. Status quo of foreign static standards

① American General Standards about ESD Control

In 2007, ESDA conducted comprehensive revision for S20.20:1999 and issued 2007 revised edition, as a result, the standard becomes more simple with strong commonality. In August 2014, the 2014 new edition was issued to increase and revise partial technical requirements, as well as intensify product certification and other management requirements.

- NASA Aerospace ESD Control Standard

NASA announced to accept the attached S20.20:1999 as ESD protection standard of NASA in February 2002, meanwhile, NASA-STD-8739.7:1997 (ESD standard issued by NASA) was abolished. When 2007 edition S20.20 was promulgated, NASA announced to implement the new edition S20.20

Background

2. Status quo of foreign static standards

⑱ General Standards about IEC and European ESD Control

In 2007, IEC 61340-5-1 promulgated the latest revision edition on the basis of absorbing ANSI standard, therefore, it was completely consistent with ANSI/ESD S20.20:2007 in the structure, contents and technical requirements. Moreover, the new edition of attached standard IEC TR61340-5-2:2007 User Guideline was also issued to serve as the technical report of IEC, as a result, which provided guideline for IEC 61340-5-1:2007 implementation.

ANSI/ESD Standard as the guidance, the International ESD protection Standard has formulated the systematic control schemes, testing method and other standard systems to represent the cutting-edge level of international static protection, therefore, it is deemed as the ESD protection standard with the widest application in the international scope, and is regarded as the main reference by other international organizations and countries (including China).

Background

3. Basic conditions of national standard formulation

- Standard formulation foundation

Q/W 1300-2010 *ESD Protection System Management Requirements*, Q/QJA 118-2013 *ESD Protection Management System Requirements for Aerospace Electronic Products* and Q/QJA 119-2013 *ESD Protection Technical Requirements for Aerospace Electronic Products* have been put into practice for 5 years.

- Succession of domestic standards

It has referred to GJB 1649 and taken the succession and consistency with GJB into account.

- International standards adoption conditions

It is consistent with ANSI/ESD S20.20:2014 and IEC 61340-5-1:2007 ; follow the step of of the latest requirements about international ESD protection management and technology.

As a member of IEC Organization, China has considered to apply equivalent transformation IEC standards, however, China is inclined to enhance management and technical requirements on the basis of IEC in consideration of the strict requirements of China Aerospace.

GB/T 32304 Standard Interpretation

GB/T 32304 Standard Interpretation

1. Scope

- GB/T 32304 Standard includes the general requirements of ESD protection for aerospace electronic products, planning, training, anti-static working areas, packaging, marking, purchasing, outsourcing, monitoring, measurement, auditing, management review and improvement, as well as other detailed technical and management requirements.
- GB/T 32304 Standard is applicable to the purchasing, production, inspection, testing, failure analysis, packaging, marking, maintain, storage, distribution, transportation, other scientific research and production activities about aerospace ESD sensitive electronic products. What's more, it is also served as the evaluation or auditing basis for ESD protection management system.

GB/T 32304 Standard Interpretation

3. Technical requirements of ESD protection

- Origination
- Document
- ESD protectiontargets
- Identification
- Training
- The EPA -- general principles, partition, configuration, ground connection/equipotential connection system, personnel grounding, tools and equipment grounding, EPA management, etc.
- Packing
- Logo
- Purchasing and outsourcing
- Monitoring and measurement
- Review
- Management review
- Improvement

12 elements

GB/T 32304 Standard Interpretation

3. Technical requirements of ESD protection

- EPA--ground connection/equipotential connection system

Table 1 Ground connection/equipotential connection system requirements

Technical requirements	Implementation method	Required limiting value
Ground connection/equipotential connection system	Protective grounding line	Comply with the safety requirements of power supply
	Functional earth	Comply with the safety requirements of power supply
	Equipotential connection	<1x10^2 Ω

* The maximum resistance value on the common connection points delivered by anti-static articles, equipment & devices shall be less than 1x10^2Ω, however, as for the static protection, the foregoing resistance is absent of minimum value, instead of determining the minimum resistance value as required by safety protection according to the related safety requirements

- EPA--personnel grounding
  - During operation on the working station, the operator shall wear wrist strap, and the grounding resistance shall satisfy $1 \times 10^6\ \Omega \sim 3.5 \times 10^7\ \Omega$.
  - Due to the floor-shoe beam system grounding, the grounding resistance can satisfy $1 \times 10^5\ \Omega \sim 1 \times 10^8\ \Omega$, and the human body voltage is less than 100V.
  - When anti-static clothing is applied to realize personnel grounding, the total resistance on the grounding points, including personnel, anti-static clothing and grounding line shall be less than $3.5 \times 10^7\ \Omega$.

GB/T 32304 Standard Interpretation

3. Technical requirements of ESD protection

- EPA--tools and equipment grounding
  - The anti-static electric soldering iron, solder sucker, active wire stripper (hot stripper) and other tools which apply alternating current shall be reliably grounded, besides, the resistance on the grounding points of tools' operative surface (or the surface contacted with ESDS electronic products) shall be less than 10 Ω.
  - The tools which don't use alternating current, including hand-operated tools (such as, flat-nose pliers, wire cutters, tweezers, fixtures, etc.), Pneumatic tools and battery-driven tools shall be grounded via anti-static table-board or the personnel who use tools. Supposing that the tools are fixed on the anti-static workbench or used by operators, the resistance on the grounding points with operating surface (or the surface contacted with ESDS electronic products) shall be less than $1 \times 10^9\ \Omega$.
  - The equipment in EPA shall be reliably grounded, and the resistance on the grounding points which are contacted with ESDS electronic products shall be less than $1 \times 10^9\ \Omega$.

GB/T 32304 Standard Interpretation

3. Technical requirements of ESD protection

- EPA classification requirements
  - Class I: Directly or indirectly contacting and disposing regions about ESDS components and elements (circuit board, etc.). Such as, warehouse, element selection, aging and testing, installation, circuit board debugging, repairing, inspection, cleaning, single-machine debugging, as well as the cable regions which are directly connected with ESDS single machine.
  - Class II: Disposing regions about ESDS single-machine equipment (ESDS elements and components have been protected). Such as, single-machine environmental test, single-machine aging, product subassembly and final assembly with static sensitive requirements, single-machine warehouse, etc.
- EPA configuration requirements

The different EPAs have different configuration schemes.

GB/T 32304 Standard Interpretation

Table 2 EPA Configuration Requirements

SN	Required item	Class I EPAP	Class II EPAP	Selection conditions
1	Logo	●	●	-
2	Anti-static ground	●	●	-
3	Anti-static workbench	●	●	-
4	Anti-static storage rack	●	●	-
5	Anti-static chair stools	●	○	-
6	Anti-static mobile device	▲	○	Transship the unprotected ESDS electronic products in EPA
7	ESD protection indicator	●	○	-
8	Anti-static clothing and cap	●	●	-
9	Anti-static shoes	●	●	-
10	Anti-static shoe cover/ walkwell bands	●	●	-
11	Anti-static gloves and finger tips	▲	▲	It is obligatory when there is cleanliness requirements
12	Anti-static wrist strap	●	●	-
13	Anti-static tools	●	○	-
14	Anti-static ion blower fan	▲	○	It is obligatory when ion distinction are disposed and the operation which is not convenient to grounding is conducted.
15	Anti-static coating and resistance reducing agent	○	○	-
16	Temperature measurement instrument	●	●	-
17	General-purpose tester for electrostatic on human body	●	●	-
18	Wrist strap tester		●	-
19	Static continuous monitor	▲	--	The electronic assembly workshop is obligatory
20	Electric soldering iron tester	▲	--	The electronic assembly workshop is obligatory
21	Non-contact electrostatic voltmeter	▲	○	One tester shall be used for the daily monitoring at least

Note: ● means obligatory; -- means not required; ▲ means in matters-of-spell which; ○ is easy optional, however, which shall depend on the specific conditions of all units, such as, static sensitive voltage of components, the number of operators, etc.

GB/T 32304 Standard Interpretation

3. Technical requirements of ESD protection

- Technical requirements about anti-static articles, equipment and facilities in EPA
  - The limiting values of the technical requirements are suitable for the ESD protection technical requirements when the static sensitive degree is HBM 100V and above, CDM 200V and above as well as 35V and above on the isolated conductor.
  - When the ESDS products which have higher static sensitivity are disposed, it is necessary to increase control projects or adjust the limiting values.
  - The products will be considered to comply with the standard requirements as long as the design documents about special disposal process and disposal projects, as well as verification report are provided.

Table 3 Technical requirements about anti-static articles, equipment and facilities in use

Name	Certification Requirement of Product	Monitoring and measurement requirements (compliance verification)
Ground (floor and ground mat)	Point-to-point resistance $1x10^6\Omega$ - $1x10^9\Omega$	Point-to-point resistance $1x10^6\Omega$ - $1x10^9\Omega$
	Point-to-grounding point resistance $1x10^6\Omega$ - $1x10^9\Omega$	Point-to-ground resistance $1x10^6\Omega$ - $1x10^9\Omega$
	Human body moving voltage <100V	–
Workbench (table-board and cushion)	Point-to-point resistance $1x10^6\Omega$ - $1x10^9\Omega$	Point-to-point resistance $1x10^6\Omega$ - $1x10^9\Omega$
	Point-to-grounding point resistance $1x10^6\Omega$ - $1x10^9\Omega$	Point-to-ground resistance $1x10^6\Omega$ - $1x10^9\Omega$
	The residual voltage after charging isolated conductor is separated is less than 200V	–
Storage rack (for the unprotected ESDS products)	Point-to-point resistance $1x10^6\Omega$ - $1x10^9\Omega$	Point-to-point resistance $1x10^6\Omega$ - $1x10^9\Omega$
Chair stools	Point-to-grounding point resistance $1x10^6\Omega$ - $1x10^9\Omega$	Point-to-ground resistance $1x10^6\Omega$ - $1x10^9\Omega$
Anti-static mobile equipment (such as, trolley, stairs, etc.)	Point-to-point resistance <$1x10^9\Omega$	Surface-to-point resistance <$1x10^9\Omega$
	Point-to-grounding point resistance <$1x10^9\Omega$	
ESD protectionpackaging	The point-to-point value on the surface with ESD is $1x10^4\Omega$ - $1x10^{14}\Omega$	The point-to-point resistance on the internal and external surface is < $1x10^{14}\Omega$
	The inductive energy of anti-static shielding packaging is less than 30nJ	
Anti-static clothing and cap	Point-to-point resistance $1x10^4\Omega$ - $1x10^{14}\Omega$	Point-to-point resistance $1x10^4\Omega$ - $1x10^{14}\Omega$
Grounded anti-static clothing	Point-to-grounding point resistance $1x10^4\Omega$ - $1x10^9\Omega$	Point-to-ground resistance $1x10^4\Omega$ - $1x10^9\Omega$
Grounded anti-static clothing system	$1x10^4\Omega$ - $3.5x10^7\Omega$	$1x10^4\Omega$ - $3.5x10^7\Omega$

Name	Certification Requirement of Product	Monitoring and measurement requirements (compliance verification)
Anti-static shoes	Shoe sole resistance $1x10^6\Omega$ - $1x10^9\Omega$	Shoe sole resistance $1x10^6\Omega$ - $1x10^9\Omega$
Anti-static shoe covers and heel bands	Conductive band resistance of shoe sole $1x10^5\Omega$ - $1x10^7\Omega$	Shoe sole conductive band resistance $1x10^5\Omega$ - $1x10^7\Omega$
Anti-static gloves, fingertips	Point-to-point resistance on the inner and outer surface $1x10^6\Omega$ - $1x10^9\Omega$	Point-to-point resistance on the inner and outer surface $1x10^6\Omega$ - $1x10^9\Omega$
Anti-static wrist strap	End-to-end resistance on the wrist strap cable ($0.8 \sim 1.2$) x $10^6\Omega$	End-to-end resistance on the wrist strap cable ($0.8 \sim 1.2$) x $10^6\Omega$
	Resistance of wrist strap cover inner surface - cable clips <$1x10^9\Omega$	Resistance of wrist strap cover inner surface - cable clips <$1x10^9\Omega$
	Resistance of wrist strap cover outer appearance - ground >$1x10^7\Omega$	Resistance of wrist strap cover outer appearance - ground >$1x10^7\Omega$
Wrist strap jack	Resistance of the wrist strap jack- grounding point<2 Ω Withdrawal force between wrist strap plug and jack socket >1.5 N	Resistance of the wrist strap jack- ground <2 Ω Withdrawal force between wrist strap plug and jack socket >1.5 N
Electric soldering iron, solder sucker, hot stripper, unsolder and other hand-operated punctiform tools	Resistance of the contact surface - ground with ESDS electronic products <2 Ω Contact surface voltage with ESDS electronic products <20 mV Leakage current on the contact surface with ESDS electronic products <10 mA	Resistance of the contact surface - ground with ESDS electronic products <10 Ω
Tweezer, buttrush, plier, clamp and other hand-operated tools	Resistance of the contact surface - grounded parts with ESDS electronic products < $1x10^9\Omega$	Resistance of the contact surface - ground with ESDS electronic products < $1x10^9\Omega$
Automatic pick-up and placing, automatic electric fitting, environment test and other equipment	"	Resistance of the contact surface - ground with ESDS electronic products < $1x10^9\Omega$
Ion fan	The static decay time is not more than 20s (decay from ± 1000V to ± 100V)	The static decay time is not more than 20s (decay from ± 1000V to ± 100V)
	The residual voltage is not more than ± 35V	The residual voltage is not more than ± 35V
Static continuous monitor	The users or product manual shall make regulations	The users or product manual shall make regulations

GB/T 32304 Standard Interpretation

3. Technical requirements of ESD protection

- Anti-static articles, equipment and devices inspection period in EPA
  - **Continuous:** Temperature, relative humidity.
  - **Daily:** Grounding resistance of human grounding connection, electric soldering iron and other electric tools when the ESD protectionshielding packaging appearance is complete and the operators have worn wrist straps.
  - **Monthly:** Power protection resistance of anti-static ground (floor and ground mat) grounding connection, anti-static workbench (table-board and cushion) grounding connection, as well as public grounding point.
  - **Half a year:** Anti-static chair/stool grounding resistance, anti-static mobile equipment (trolley, stairs, carrier and crane) surface grounding resistance, wrist strap jack, tweezer and other hand-operated tools grounding resistance.
  - **One year:** Point-to-point/point-to-ground resistance of the anti-static ground (floor and ground mat) and anti-static storage rack, the grounding resistance of anti-static chairs/stools, general-purpose tester for electrostatic on human body/wrist strap tester/electric soldering iron tester/static continuous monitor and other technical performance, etc.

GB/T 32304 Standard Interpretation

Table A.1 Anti-static articles, equipment and facilities test period in EPA

Project requirements		Test period				
		Continuous	Daily	Monthly	Half a year	One year
Anti-static ground (floor Grounding connection		-	-	●	-	-
and ground mat) Point-to-point and point-to-ground resistance *		-	-		-	●
Anti-static workbench Grounding connection		-	-	●	-	-
(table-board and cushion) Point-to-point and point-to-ground resistance *		-	-		-	●
Point-to-point and point-to-ground resistance of anti-static storage rack *		-	-			●
Grounding resistance of anti-static chair stools *		-	-		●	-
Grounding resistance of anti-static mobile equipment (trolley, stairs, carrier and crane) surface *		-	-		●	-
Point-to-point resistance and ESD shielding function on the surface of turnover container and other ESD protectionpackaging		-	-		-	○
Appearance completeness of ESD protectionshielding packaging		-	●		-	-
Human body's grounding connection when operators have worn wrist strap		-	●		-	-
Wrist strap jack		-	-		●	-
Anti-static clothing Personal dressing conditions		-	●		-	-
Point-to-point resistance or point-to-ground resistance		-	-		-	-
Human body's grounding connection when operators have worn anti-static clothing		-	●		-	-
Grounding resistance of electric soldering iron and other electric tools		-	●		-	●
Grounding resistance of tweezer and other hand-operated tools		-	-		●	-

GB/T 32304 Standard Interpretation

Grounding resistance of automatic picking and placing, automatic electric fitting, environment test and other equipment *		-	-	-	●	-
Ion blower fan technology *		-	-	-	-	●
Static grounding system, *	Continuity and completeness	-	-	●	-	-
	Public grounding points' resistance for power supply	-	-	●	-	-
	AC equipment conductor resistance *	-	-	-	-	●
	Grounding resistance of special ground wires *	-	-	-	-	●
General-purpose tester for electrostatic on human body *		-	-	-	-	●
Static continuous detector	Operating condition	-	●	-	-	-
	Technical performance	-	-	-	-	●
Non-contact electrostatic voltmeter technology *		-	-	-	-	●
Environment temperature, relative humidity *		●	-	-	-	-

Note: ● means obligatory, - means not required, ○ means random inspection in batches. It is requested to shorten inspection period according to the using mode, conditions, frequency and age limit of static articles, equipment and devices.

† The inspection identification, nameplate or recording table in certain form is required.

‡ EPA grounding resistance (namely the resistance between grounding body and ground) shall be inspected every year. Supposing that there is no condition to continuously record.

‡ EPA temperature and relative humidity, the timing records shall be conducted twice at least every day.

Standard Instructions

Standard Instructions

1. Using range of standards

- GB/T 32304 is the national standard in Chinese aerospace field.
- GB/T 32304 shall be implemented from July 1, 2016.
- Proposed by: China Aerospace Science and Technology Corporation.
- Centralized organization: National Aerospace Technology and Application Standardized Technology Committee (SAC/TC 425)
- Drafted by: Beijing Orient Institute of Measurement and Test and Xi'an Institute of Space Wireless Technology

↓

No. 514 Institute of China Academy of Space Technology of CASC

ESD Protection Product Certification

Standard Instructions

3. ESD protection product certification

- Certification type
  Voluntary product certification
- Certified products
  ESD protection products
- Certification mode
  Type test + supervision after certificate obtaining
- Issuing authority
- Certification and Accreditation Administration of the People's Republic of China, March 8, 2016

Standard Instructions

3. ESD protectionproduct certification

- Designated institutions for certification: Beijing Oriental Institute of Measurement and Test (No.514)

Standard Instructions

3. ESD protection product certification

- Certified products (product test standard)
  - Anti-static clothing
    - GB 12014-2009 *Anti-static Clothing*
  - Anti-static working cap
    - GB/T 31421-2015 *Anti-static Working Cap*
  - Anti-static gloves
    - GB/T 22845-2009 *Anti-static Gloves*
  - Anti-static shoes (conductive shoes)
    - GB 21146-2007 *Personal Protective Equipment-Occupational Footwear*
  - Anti-static turnover container
    - SJ/T 11277-2002 *General Specification of Anti-static Turnover Container*

Anti-static products Manufacturing enterprise

Standard Instructions

3. ESD protection product certification

- Certified products (product test standard)
  - Anti-static raised floor
    - SJ/T 10796-2001 *General Specification of Anti-static Raised Floor*
  - Anti-static laminated board
    - SJ/T 11236-2001 *General Specification of Anti-static Laminated Board*
  - Anti-static floor coating
    - SJ/T 11294-2003 *General Specification of Anti-static Floor Coating*
  - Anti-static ceramic tiles
    - GB 26539-2011 *Anti-static Ceramic Tiles*
  - Anti-static packing tubes of integrated circuits
    - SJ/T 10147-91 *Anti-static Packing Tubes of Integrated Circuits*
    - …… ……

Anti-static products Manufacturing enterprise

Standard Instructions

3. ESD protection product certification

- Whole performance inspection of ESD protection products (state test center)
  - Electrical property (static voltage, resistance, decay time, energy, etc.)

Standard Instructions

3. ESD protection product certification

- Whole performance inspection of ESD protectionproducts (state test center)
  - Mechanical/physical performance (strength, fold resistance, abrasion resistance, impact resistance, aging resistance, etc.)

Standard Instructions

3. ESD protection product certification

- Whole performance inspection of ESD protection products (state test center)
  - Chemical performance (pH, formaldehyde contents, Azo dye)

Standard Instructions

3. ESD protection product certification

- Certification results admissibility range
  - China Academy of Space Technology and its outsourcing units
    - Units of 5th Academy, CASIC, CETGC, China Academy of Sciences, Headquarters of the General Staff and other units
  - China Aerospace Science and Technology Corporation
    - First Academy, Fourth Academy, Sixth Academy, Seventh Academy, Eighth Academy, Ninth Academy and Eleventh Academy, etc.
  - National electronic industry ESD protection products users
- Product certification and promotion progress
  - Take the lead in forming product certification admission system in the aerospace field and set product quality threshold;
  - After that, carry out certification in the national defense military engineering system gradually when the national standard is widely adopted and used;
  - Finally, form ESD protection product quality certification commonsense in the national electronic industry field.

Thank you!

泰瑞 L.威尔舍

1978 年，泰瑞 L.威尔舍博士在贝尔实验室开始了他的职业生涯，研究绝缘聚合物的电传导机制和电气互连材料的电解腐蚀失效机制，1984 年，由于在其领域的出色工作而被授予荣誉技术工人。1986 年，他被晋升为技术经理，重组贝尔实验室的静电放电（ESD）领域的核心专长。新成立的小组做出了一系列开创性贡献，在推动行业标准发展方面起到了关键作用。1994，其小组业务拓宽到了朗讯科技公司硬件可靠性方向的各个方面，尤其着重发展环境压力测试（EST）和产品可靠性预测与规划。1997 年，被晋升为质量、测试及可靠性中心主任，负责朗讯科技公司业务部门的产品质量、测试和可靠性保证措施的发展和部署，工作内容包括集成电路、电路板和系统级测试和诊断的可测性设计，射频与光电系统和元件测试等特殊技术的可测性设计，于 2001 年离职。离开朗讯后，威尔舍博士成为 Lasersharp 公司（一家光纤激光放大器公司）可靠性中心主管，负责确保产品的质量、可靠性和适应性。2004 年开始担任 Dangelmayer Associates(丹格尔迈尔有限责任公司)—EOS/ESD 咨询公司—高级副总裁。

威尔舍博士曾担任 1988-1989 ESD 协会标准委员会主席，1991 年担任技术程序主席，1992 年担任副主席，1993 年担任 EOS / ESD 研讨会大会主席。1993-1995 年担任研讨会理事会成员。他也积极参与各类组织机构的活动，诸如优化 Sematech、 ESD 协会、JEDEC 14 质量和可靠性委员会等组织的质量标准、为其规划路线图等。1999 年至 2001 年担任 JEDEC 理事会理事。威尔舍博士目前是 JEDEC / ESDA HBM ESD 工作组和 CDM ESD 工作组的联合主席，EOS/ESD 协会理事会成员和前任主席。其最近牵头致力于协调与整合 JEDEC 和 ESDA 的设备测试标准。威尔舍博士获得了佛罗里达州立大学化学学士学位和得克萨斯大学奥斯汀分校化学物理学博士学位。在固体物理、应用数学、有机化学、电子产品可靠性和静电放电等领域发表或联合发表了四十篇论文。

Terry L. Welsher

Dr. Terry L. Welsher retired from Lucent Technologies-Bell Laboratories Engineering Research Center in 2001 as the director of the quality, test & reliability department. He began his career in Bell Labs in 1978; where he worked on electrical conduction mechanisms in insulating polymers and electrolytic corrosion failure mechanisms in electrical interconnection materials. In 1984, he was appointed distinguished member of technical staff for his work in these fields. In 1986, he was promoted to technical manager to re-constitute the Bell Laboratories core expertise in electrostatic discharge (ESD). The newly formed group proceeded to produce a string of ground-breaking contributions to the field and played a key role in advancing industry standards. In 1994, he broadened his group's activities to all aspects of hardware reliability for Lucent Technologies with special emphasis in environmental stress testing (EST) and product reliability prediction and planning. In 1997, he was promoted to director of the quality, test & reliability center of excellence where he directed the development and deployment of product quality, test and reliability assurance practices for Lucent Technologies business units. This work included design for testability of integrated circuits, board and system level test and diagnosis and special techniques for testing of RF and optoelectronic systems and components. After leaving Lucent, he became reliability director for LaserSharp Corporation, an optical fiber laser amplifier company, where he was responsible for product quality, reliability, and compliance. Since 2004, he has been senior vice president of Dangelmayer Associates, LLC, an EOS/ESD consulting firm.

Dr. Welsher was chairman of the ESD Association standards committee 1988-1989. He was technical program chair in 1991, vice general chair in 1992, and general chair in 1993 of the EOS/ESD Symposium. He served as member of the Symposium board of directors 1993-1995. He has also been active in quality standards and roadmapping activities with Sematech, the ESD Association, and the JEDEC 14 quality and reliability committee. He served on the board of directors of JEDEC 1999-2001. He is currently co-chair of the joint JEDEC/ESDA HBM and CDM ESD working groups, vice president of the ESD Association, and a member of the board of directors of iNARTE, a telecommunications technical certification organization. Recently, he has led the effort to harmonize and merge JEDEC and ESDA device testing standards. He holds a BS in chemistry from Florida State University and a PhD in chemical physics from the University of Texas at Austin. He is author or co-author of forty papers in solid state physics, applied mathematics, organic chemistry, electronics reliability, and electrostatic discharge.

如何面对超敏感静电产品的静电防护

Terry Welsher
旦格梅尔联合公司
www.dangelmayer.com

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概要

1. 问题陈述
2. 静电放电（ESD）分级和临界值
3. 磁阻磁头（MR head）的经验教训
4. 测量和应对措施回顾
5. 结论和疑问

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问题陈述

p3

问题陈述/疑问

- 半导体装置对静电放电越加敏感（其中一些更是“超敏感”）
- 很多制造商面临着制造和处理这些装置的问题
- 现已出版的一些静电放电控制标准（根据其适应范围）已声明不适用于低于特定临界值水平的情况
- 这些方案中的哪些变化或强化措施对于处理超敏感装置来说是必要的？

S20.20 适用范围

·本文件适用于处置静电放电敏感电压不低于人体模型（HBM）100V、带电器件模型（CDM）200V和孤立导体35V的电子元器件、组件和设备的制造、加工、组装、装联、包装、标识、维修、测试、检验、运输等科研生产活动。对于敏感电压低于上述电压值的电子产品的处置，如调整了限值范围或采取了附加控制方法，仍可认为符合本标准的要求。

S20.20 适用范围注解

·（此类）装置的评级源于理想化的测试方法，多数情况下，这些方法能够代表了最恶劣的情况，这就造成了不确定的安全裕度。

·适用范围极限以电压的形式给出，但泄放电流（往往难以测得）却是更加重要的参数。

静电放电的分级和临界值

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人体模型的静电放电分级 (2016*)

分级	电压范围(V)
0Z	<50
0A	50 to < 125
0B	125 to < 250
1A	250 to < 500
1B	500 to < 1000
1C	1000 to < 2000
2	2000 to < 4000
3A	4000 to < 8000
3B	≥ 8000

*JEDEC和ESDA投票过程中

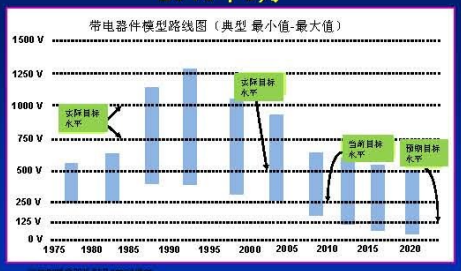
带电器件模型的静电放电分级 (2014)

分级等级	电压范围(V)
C0A	< 125
C0B	125 to <250
C1	250 to <500
C2A	500 to <750
C2B	750 to <1000
C3	>=1000 (见注解3)

已报告的高于1000V的带电器件模型的临界值无效1

ANSI/ESD/JEDEC JS-002-2014

带电器件模型技术路线图 2016年5月



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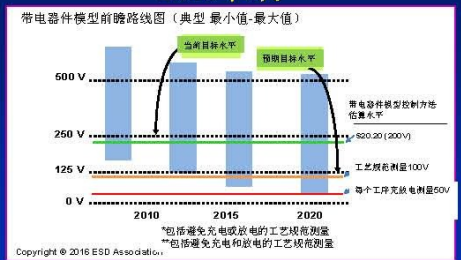
带电器件模型技术路线图 2016年5月



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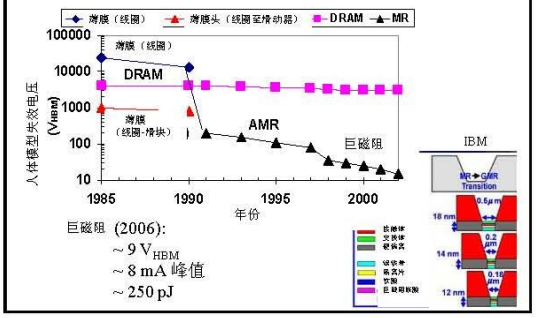
磁阻磁头的经验教训

p12

磁阻磁头静电放电: 时间线



巨磁阻 (2006):
~ 9 V_{HBM}
~ 8 mA 峰值
~ 250 pJ

磁阻磁头的经验教训

- 传统静电放电方法是必要的但也存在不足:
  - 低于 100 V
  - 电离 –在一些应用实践中是必要的但有不足
- 期待在100V上打破常规思维
  - 假设装置仍继续充电！
- 虽没有发明新的控制技术，但是…
- （有了）新的控制重点和监控
  - 消除了金属与金属的接触
  - 使用耗散性材料进行“软着陆”
  - 先进的测试方法
    - 电磁干扰（EMI）/静电放电事件检测
    - 放电电流测试方法

pl4

单一测量VS连续测量

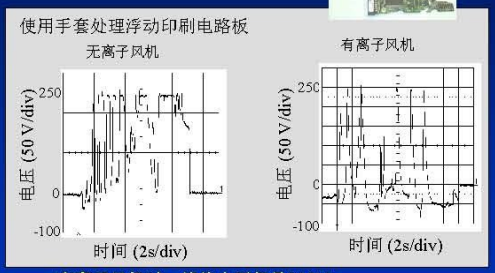
对于静电放电的混淆和迷惑通常源于单一测量方法的不足！

- 图片VS视频
- 请试着弄清楚戏剧里发生了什么
  - 情景一：几张图片
  - 情景二：整个戏剧的视频录影
- 如果戏剧没几个动作…还好
- 如果戏剧有很多动作…错误的解读
  过程步骤= 剧场

pl5

印刷电路板（PCB）＋丁腈手套

使用手套处理浮动印刷电路板



•有离子风机时，峰值电压仍是250V！
•处置0级装置时别指望离子风机！

pl6

测量电流瞬变

需要一个高带宽的电流探针和观察快来测量短暂的金属接触电流瞬间变化！

电流探针：
- 自制同轴探针(500 Mhz)
- 泰克公司: Ct-1(1ghz), CT-6 (2ghz)
- 费舍尔通讯的 F-65 (1ghz)


同轴电流探针


纳库仑计的尖头

静电释放枪尖头穿过F-65

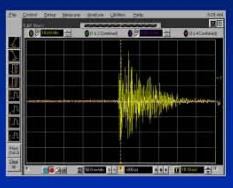
费舍尔 F-65 钳式


CT-6

pl7

静电放电事件检测
出色的连续性测量

- 基于：任何静电放电事件都会产生射频（RF）信号
- 非接触方法用于审计/监视、排放和流程鉴定
- 非侵入式测量通常可远程作用于设备外部
- 可以确定时间、强度和位置



pl8

事件检测类型

昂贵
复杂

- 高速示波器+天线
- 多频段高速示波器 + 多重天线

廉价
简单

- 简单事件计数器
- 能够捕捉一些事件强度信息的事件监视器
- 有数据获取功能的事件计数器和监视器
- 远程电压传感器

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静电放电事件检测可选项

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事件检测陷阱

- 假阳性事件
- 敏感度设置
  - 范围
- 背景噪音
  - 步进电机
  - 继电器
  - 手机
  - 灯开关
  - 射频信号
- 静电放电电压/电流未知
- 区别
  - 有威胁和无威胁事件
    - 与ESDS元件无关的静电放电

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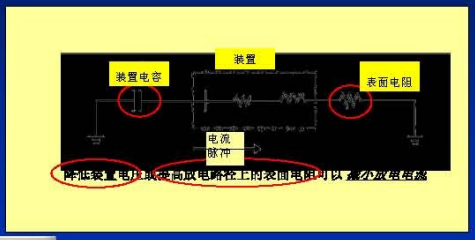
减缓带电器件放电
两种策略



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金属间接触–更高的0Z级自动操作偏差风险

防静电替代材料– 静电消散材料
0Z, 0A级的成功解决方案

0A, Z 级静电放电控制基础
(控制接触电阻)

- 定制化要求
  - 两个减缓策略 – 电压 & SRM 限值
- 强化培训
- 最低 SRM 限值 > 10^4 欧姆
  - 0Z 级装置
  - 电路板
- 持续监控&金属腕带
- 降低最大场限
- 更严格的离子风机残余电压要求
- 静电放电事件检测审计要求

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0A级静电放电控制基础

- 未能对浮动装置/工具进行接触电阻)
  - 能够满足0A级
  - 通常离子化太慢或未能完全覆盖
  - 必须假设装置电压不是0
  - 为防止静电放电，必须（控制），
    - 无论装置、工具或环境的电压（是多少）
- 设计装置和流程的接触电阻
  - 消散材料
- 把时间花在最有效果的地方
  - 注意细节
  - 关注与（静电敏感）装置接触的装置和工具
  - 其次控制周围环境
- 强化日常的符合性验证至关重要

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0A级电离

- 静电消散材料能解决问题么？
  - 如果不能，考虑电离
- 确定有无电离的效果
  - （电磁）场计
  - 电磁干扰事件检测
- 传统离子风机消散电压
  - 少于±25V，可能不够低
  - 日冕（Corona）离子风机可达 < 1 V
  - 原子能（nuclear）离子风机可以达到0V
- 消散电压应选择大多数敏感装置的1/2到1/10
  - 例如50V的装置需要 ± 5 V的消散电压
- 流程和瞬间时间兼容
  - 对于流程来说足够快

磁阻磁头对 ICs的启示

- 已证实即使是最敏感的装置（<1V）原则上也能够大规格大产量的进行生产
- 磁阻磁头对于ICs有主要优势
  - 装置简单、振动小– 然而很多同期在产的典型ICs却复杂
  - 静电放电故障几乎能够立即被检测到，较短的反馈环节能够改进流程–然而ICs故障检测和分析却难得多，反馈环节长或开放。
  - 一旦包装入硬盘驱动器组件便相对安全(在 CBE 问题上)

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0A级及以下的关键需求：

- 装置信息的需求 (尤其是带电器件模型， 很遗憾尚缺乏行业信息)
- 新品介绍的先行信息
- 更严格的流程分析
- 先进的测量方法
- 理解控制策略的极限（例如电离）
- 先进的对策

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0A 和 0Z级的对策
两个关键注意事项

- 强化日常符合性验证
  - 月度内部审核
  - 日常 SPC (统计过程控制)
- 对于以下有全面的技术理解:
  - 应对措施选项
    - 电压控制
    - 耗散性接触电阻
      - 在装置或电路板的接触点上
  - 技术要点
    - CDM; CBE; CDE; HBM
    - 预先设定测量方法
    - 耐压、耐电流装置

p30


疑问？
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terry@dangelmayer.com

Facing the Challenge of Electrostatic Protection of Ultra-Sensitive Devices

Terry Welsher
Dangelmayer Associates
www.dangelmayer.com

p1

Outline

1. Problem Statement
2. ESD Classifications and Thresholds
3. MR Head Lessons Learned
4. Review of Measurements and Countermeasures
5. Conclusion & Questions

p2

Problem Statement

p3

Problem Statement/Question

- Semiconductor devices are becoming more sensitive (some "ultra-sensitive") to ESD
- Many manufacturers are facing producing and handling these devices
- Current published ESD control standards are not declared (by their scope) to be effective below certain threshold levels
- What changes or enhancements of these programs will be necessary to handle "ultra-sensitive" devices?

S20.20 Scope

•This document applies to activities that manufacture, process, assemble, install, package, label, service, test, inspect, transport or otherwise handle electrical or electronic parts, assemblies and equipment susceptible to damage by electrostatic discharges greater than or equal to **100 volts HBM, 200 volts CDM,** and 35 volts on isolated conductors. **Activities that handle items that are susceptible to lower withstand voltages may require additional control elements or adjusted limits.** Processes designed to handle items that have an ESD sensitivity to lower withstand voltages can still claim compliance to this standard.

S20.20 Scope Comments

•The ratings assigned to devices come from idealized test methods which, in many instances, represent worst case scenarios. This provides some undefined safety margin.

•The scope limits are given in voltage but the more important parameter (often harder to measure) is discharge current.

ESD Classifications and Thresholds

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ESD HBM Classification (2016*)

Classification	Voltage Range (V)
0Z	<50
0A	50 to < 125
0B	125 to < 250
1A	250 to < 500
1B	500 to < 1000
1C	1000 to < 2000
2	2000 to < 4000
3A	4000 to < 8000
3B	≥ 8000

*In JEDEC and ESDA ballot processes.

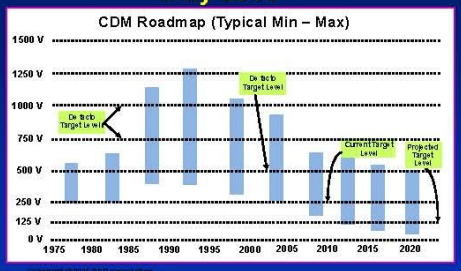
ESD CDM Classification (2014)

Classification Level	Voltage Range (V)
C0A	< 125
C0B	125 to <250
C1	250 to <500
C2A	500 to <750
C2B	750 to <1000
C3	>=1000 (see Note 3)

CDM Thresholds Reported above 1000 volts are not valid!

ANSI/ESD/JEDEC JS-002-2014

CDM Technology Roadmap May 2016



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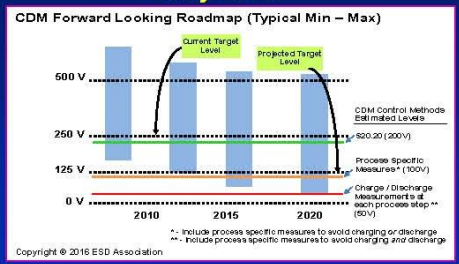
CDM Technology Roadmap May 2016



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MR Head Lessons Learned

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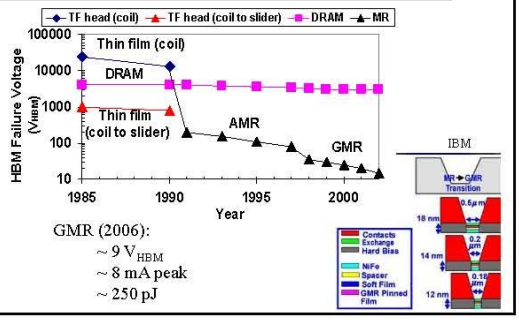
MR Head ESD: Timeline



GMR (2006):
~ 9 V_{HBM}
~ 8 mA peak
~ 250 pJ

MR Head Lessons Learned

- Conventional ESD Methods ***Essential*** but ***Insufficient***:
  - Below 100 Volts
  - Ionization – Necessary in some application but Insufficient
- Expect a Paradigm Shift @ 100 volts
  - Assume Device Still Charged!
- No new control technologies invented but…
- New Control Emphasis and Monitoring
  - Eliminate Metal-to-Metal Contact
  - "Soft Landings" with Dissipative Materials
  - Advanced Test Methods
    - EMI/ESD Event Detection
    - Discharge Current Test Methods

pl4

Single vs. Continuous Measurements

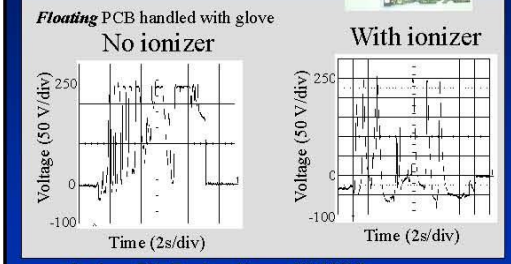
Confusion & Mystery About ESD Often
Result of Inadequacy Of Single Measurements!

- Pictures Vs. Video
- Try To Figure Out What Is Going On In A Play
  - Case 1: Small Number Of Pictures
  - Case 2: Video Movie Of Entire Play
  - If Play Has Little Motion... ok
  - If Play Has Lots Of Motion...incorrect Interpretation
    Process Step = Theater

pl5

PCB + Nitrile Glove

Floating PCB handled with glove



- Ionizer ON: Peak voltage still 250V!
- Don't depend on ionizers for Class 0 devices!

pl6

Measuring Current Transients

Need To Use A High Bandwidth Current Probe And Scope To Measure The Short Duration Metal-Contact Current Transients!

Current Probes:
- Homemade Coaxial Probe (500 Mhz)
- TEKTRONIX: Ct-1(1ghz), CT-6 (2ghz)
- Fischer Communications F-65 (1ghz)

Fischer F-65 Clamp-on

ESD Gun Tip Through F-65

pl7

ESD Event Detection
Excellent Continuous Measurement

- Based On Principle That Every ESD Event Produces An RF Signal
- Non-contact Method For Audit/Surveillance, Troubleshooting And Process Qualification
- Non-invasive Measurement Can Be Done Remotely Often Outside Equipment
- Possible To Determine Time, Strength And Location

pl8

Types of Event Detection

Expensive Complex
- High speed oscilloscope + antenna
- Multi-Channel high speed oscilloscope + multiple antennae

Inexpensive Simple
- Simple event counters
- Event monitors that capture some event strength information
- Event counters/monitors with data acquisition
- Remote voltage sensors

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ESD Event Detection Options

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Event Detection Pitfalls

- False Positive Events
- Sensitivity Settings
  - Range
- Background Noise
  - Stepper Motors
  - Relays
  - Cell Phones
  - Light Switches
  - RF Signals
- Unknown Discharge Voltage/Current
- Differentiation
  - Between Threatening and Non-threatening Events
    - ESD but not Related to ESDS Items

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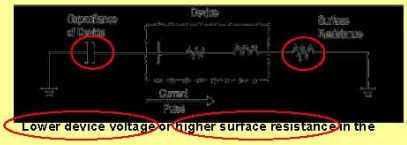
CDM Mitigation
Two Strategies



Lower device voltage or higher surface resistance in the discharge path can *reduce discharge current*.

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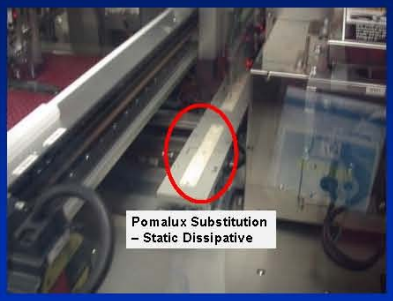
Metal-to-Metal Contact – Higher Risk for Class 0Z Automation Misalignment

Pomalux Substitution – Static Dissipative
Successful Solution for Class 0Z, 0A



Class 0A, Z ESD Control Fundamentals
(Control Contact Resistance)

- Customized Requirements
  - Both Mitigation Strategies – Voltage & SRM Limits
- Enhanced Training
- Minimum SRM Limits > 10^4 ohms
  - For Class 0Z Devices
  - For Circuit Boards
- Constant Monitors & Metal Wrist Bands
- Reduced Maximum Field Limits
- More Stringent Ionizer Balance Requirements
- ESD Event Detection Auditing Requirements

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Class 0A ESD Control Fundamentals
(Control Contact Resistance)

- Futile To Control Voltage On Floating Device/Tool
  - Sufficiently for Class 0A
  - Ionization Often Too Slow or Incomplete Coverage
  - Must Assume Device Voltage Will Not Be 0
  - Must, To Prevent ESD
    - Regardless of Voltage
      - On Device, Tool Or Environment
- Design Contact Resistance For Device And Process
  - Dissipative Materials
- Spend Time Where It Counts Most
  - Pay Attention to Details
  - Focus On Device And Tools That Touch Devices
  - Control Of Surrounding Environment Is Secondary
- Robust Daily Compliance Verification is Critically Important

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Class 0A Ionization

- Will Static Dissipative Materials Resolve The Problem?
  - If Not, Consider Ionization
- Confirm Effectiveness With And Without Ionization
  - Field Meters
  - EMI Event Detection
- Conventional Ionizer Offset Voltages
  - Less than ±25 Volts, may not be low enough
  - Corona Ionizers available to < 1 volt
  - Nuclear ionizers will give you zero volts
- Select Offset Voltages 1/2 to 1/10 Of Most Sensitive Device
  - i.e. 50 Volt Device Requires ±5 Volt Offset Voltage
- Process Compatible Decay Times
  - Fast Enough For Process Flow

MR Head Implications for ICs

- Demonstrated that even the most sensitive device (<1volt) can, in principle, be produced in high volume with high yield
- MR Heads have some major advantages over ICs
  - Simple device, little variation – while many complex ICs are typically in production at same time
  - ESD failures detectable almost immediately with short feedback loop for process improvement – while ICs failures are much more difficult to analyze, long or open feedback loops
  - Relatively safe once packaged in disk drive assembly (no CBE issues)

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Critical Needs for Class 0A and below:

- Need for Device Information (especially CDM which is sorely lacking in industry)
- Advance information on New Product Introduction
- More rigorous process analysis
- Advanced measurement techniques
- Understand limits of control strategies (e.g., ionization)
- Advanced countermeasures

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Countermeasures for Class 0A & 0Z
Two Critical Considerations

- Robust Daily Compliance Verification
  - Monthly Internal Audits
  - Daily SPC (Statistical Process Control)
- Full Technological Understanding of:
  - Countermeasure Options
    - Voltage Control
    - Dissipative Contact Resistance
      - At Point of Contact with Device/Board
  - Technical Elements
    - CDM; CBE; CDE; HBM
    - Advance Measurement Techniques
    - Device Withstand Voltages *and Currents*

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Questions
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阮方鸣

阮方鸣教授，北京邮电大学工学博士，博士生导师，日本名名古屋工业大学访问研究员；国际电子电器工程师学会高级会员(IEEE Senior Member)，亚太环境电磁学学术会议 (Asia- Pacific International Conference on Environment Electromagnetics 2012, 2015) 程序技术委员会委员，国家自然科学基金同行评议专家，国家基础电子元器件质量检验中心专家，中国通信学会电磁兼容委员会委员，中国电子学会高级会员，中国通信学会高级会员，IEEE 大数据分会会员。

作为电磁兼容研究领域的中国学者，应邀出席在欧美国家召开的多次一流电磁兼容学术会议，主要有：

2009年8月美国奥斯汀国际电子电器工程师学会电磁兼容年会(2009IEEE EMC, Austin, US),

2009年1月 瑞士苏黎世国际电磁兼容学术会议(2009 Zurich International Conference on EMC, Jan14-17, Zurich, Switzerland)

2011年9月英国约克大学召开的欧洲第10届国际电磁兼容学术会议(EMC Europe2011, York University, UK)，

2013年5月澳大利亚墨尔本亚太国际电磁兼容学术会议(2013 APEMC, Melbourne, Australia),

2012年9月意大利罗马欧洲第10届国际电磁兼容学术会议(EMC Europe2012, Rome, Italy),

2010年9月波兰弗罗茨瓦夫第9届欧洲国际电磁兼容学术会议(EMC Europe2010, Wroclaw, Poland),

2006年12月日本名古屋工业大学亚洲国际电磁兼容学术会议(2006ASEMC, Nagoya, Japan)

2014年9月瑞典哥德堡欧洲国际电磁兼容学术会议(EMC Europe 2014, Gothenburg, Sweden, Sept 1-4, 2014)

获2015年贵州省科技进步三等奖（第一获奖人），获首届贵州省高等学校科学研究优秀成果(科学技术)自然科学奖三等奖（第一获奖人）、贵州省第二届（第一获奖人）和第四届（第二获奖人）自然科学优秀学术论三等奖各一次。

以第一作者和通信作者发表学术论文83篇；主持完成和在研国家级、省市级科研项目13项；获得国家授权发明专利、实用新型专利各一项，合作出版学术译著一部。

应邀为 ICCC (世界通信大会)， APEMC(亚太国际电磁兼容学术会议)， 通信学报，电子与信息学报，物理学报，Chinese Physics B, China Communication, 天津大学学报、吉林大学学报等审稿人。

Ruan Fangming

Ruan Fangming received his BS degree in electronic engineering in July, 1982 from Guizhou University of China, received MA degree in education in July, 2006 from Guizhou Normal University of China, and received PhD Eng. degree in electromagnetic fields and electromagnetic waves in July, 2009 from Beijing University of Post and Telecommunication. He was with Liupanshui Normal College from Aug., 1982 to Feb., 2000 as an instructor and an associate professor (since 1997). In Mar., 2000 he moved to Guizhou Normal University of China. From Sept., 2004 through Sept 2005 he worked as a visiting scholar in Fujiwara Electromagnetic Environment Lab of Nagoya Institute of Technology, Japan, engaged in properties research of micro-gap electrostatic discharge. Since Dec., 2006 he has been a full professor in Guizhou Normal University. Dr. Ruan is a senior member of China Institute of Electronics (CIE), a senior member of China Institute of Communication (CIC). On Nov., 2015 Dr. Ruan was awarded IEEE senior membership.

Dr. Ruan has published more than 80 papers in academic journals and academic conferences, completed as the research team leader 11 research projects supported by national or provincial government of China, and was the inventor of 3 patents. Dr. Ruan was electromagnetic compatibility (EMC) commission member of CIC, and was a TPC member of CEEM'2012 and CEEM'2015 (Asia-Pacific Conference on Environment Electromagnetics).

Dr. Ruan was awarded 2015 Guizhou Province Third Prize of Science and Technology Advancement(with title "Mechanism and correlative properties research of electrode moving speed effect in short-gap electrostatic discharge "), and 2014 Third Prize of Science and Technology Advancement of Guizhou Universities and Colleges(with title "Mechanism research of short-gap electrostatic discharge properties"). Presently Prof. Ruan is an advisor of graduates in Guizhou University and in Guizhou Normal University, having 10 graduate students, and teaching graduate level classes on RF and microwave technology, principles and design of electromagnetic compatibility (EMC), and TeraHertz technology.

静电放电的电极移动速度效应研究和非接触静电放电标准问题初探

阮方鸣

贵州师范大学

前 言

静电放电是航空航天、工业、国防等不同领域电子系统和仪器设备的严重威胁。国际电工委员会(IEC）制定了接触放电测试的国际标准，但对于真实大量存在的非接触静电放电的测试标准，却至今未能制定出来。

小间隙静电放电的电极移动速度效应机理和相关性质研究，对于深刻掌握非接触静电放电的性质，制定非接触静电放电测试标准，和静电放电危害的防护，能够提供理论技术支撑，起到关键重要作用。

在国家自然科学基金、贵州省国际科技计划重点项目、贵州省科学技术基金等支持下，贵州师范大学电磁兼容团队经过多年努力，解决了国际电磁兼容静电放电研究领域的两个重要难题，在非接触静电放电性质研究上取得突破性和开拓性的成果。

纲 要

- 研究背景和内容
- 研究的创新性
- 研究取得的成果
- 成果的国际影响
- 研究成果的意义

背 景

- 静电放电造成损失 500亿美元/年

IEC CCC IEEE →

静电放电测试标准？ 非接触型ESD---No！

接触型ESD --- Yes

内容：电极移动速度效应/1987提出

现 象： 瑞士联邦理工 B Daout H Ryser etc

人体-金属 静电放电参数显著变化

↑ 强影响

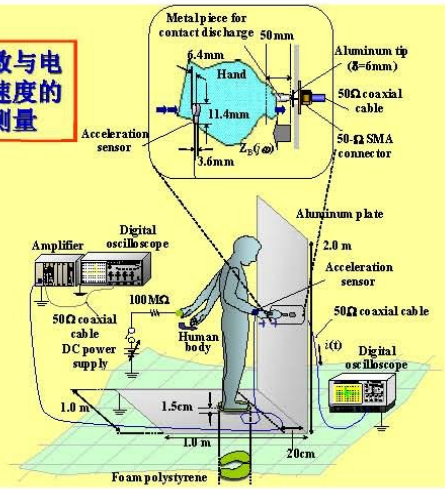
电极向靶的移动速度

↓ 强影响

静电放电模拟器的放电参数

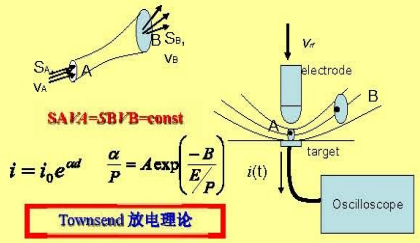
机 理：？

放电参数与电极运动速度的同步测量



研究的创新性

1. 在国际上首次提出了气体压强变化导致电极移动速度效应清晰的理论模型。

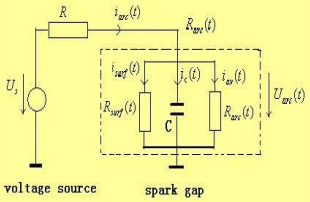


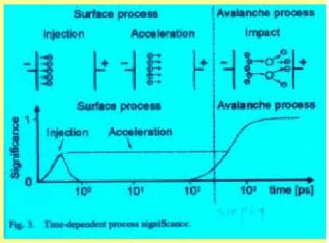
$$i = i_0 e^{\alpha d} \qquad \frac{\alpha}{P} = A\exp\left(\frac{-B}{E/P}\right)$$

Townsend 放电理论

研究的创新性

2. 发现静电放电的电压引起放电参数出现临界值现象，并用理论进行了成功的阐释，修正完善了小间隙放电模型。





研究的创新性

3. 研究并成功发明了静电放电多因素效应测试系统，解决了国际电磁兼容研究的两个重要难题

创新特点：(1) 实现放电枪真实的全直线运动，可高速向靶高速运动放电而不损坏仪器；
(2) 全封闭箱体，不同因素定量有效控制(国家已授权专利号：ZL201310015269.6)

比较1：Missouri 科技大学David Pommerenke的静电放电测试装置 (1995)

40 D. Pommerenke/Journal of Electrostatics 36 (1995) 31–54

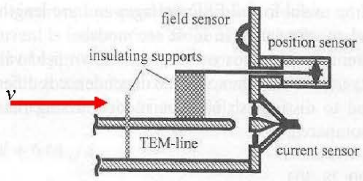


Fig. 7. Set-up for the measurement of arc length, speed of approach and discharge current.

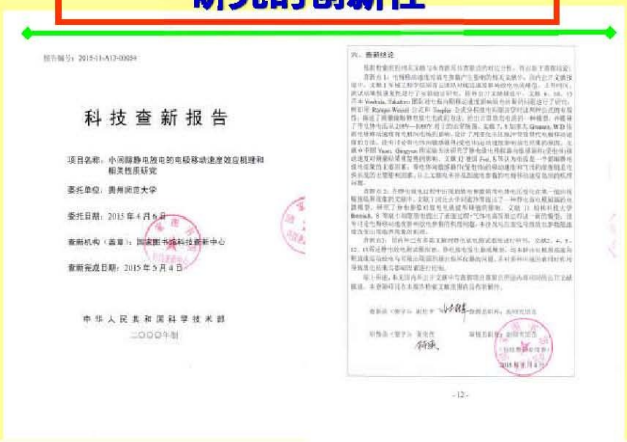
缺点：(1) 高速向靶运动可能造成仪器损坏
(2) 环境开放，不同因素难以精确控制

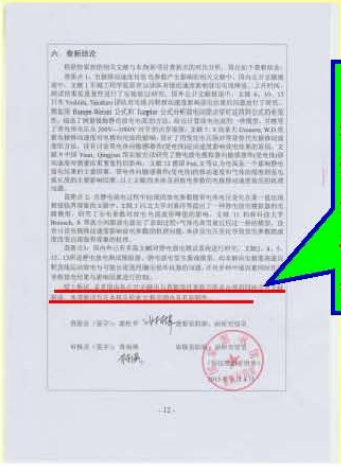
比较2：电磁环境效应国家重点实验室的静电放电测试装置(2012.11.12日北京)

存在问题：(1) 非真实直线运动；(2) 环境开放，不同因素难以精确控制

来源：2012北京静电防护与标准化学术交流讨会报告

研究的创新性





综上所述，未见国内外公开文献中与查新项目查新点所述内容相同的公开文献报道，本查新项目在本报告检索文献范围内具有新颖性。

研究取得的成果1—发表学术论文82篇

研究取得的成果1—发表学术论文检索报告


检 索 报 告

阮方鸣发表的学术论文被SCI数据库收录1篇，附刊载期刊当年影响因子；在SCI数据库中被引用12次，其中他人引用7次；被EI数据库收录39篇；被CPCI-S数据库收录23篇；在CNKI-CCD数据库被引用64次，其中他人引用36次，详见附件1-4。

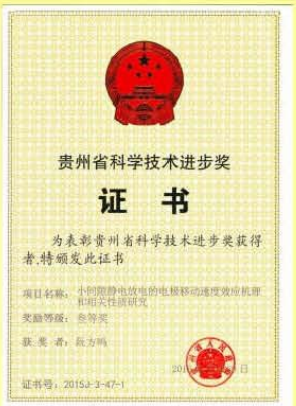
研究取得的成果1—论文收录引用情况 被国际一流学术期刊IEEE Transaction on EMC, IEICEJ等引用

成果 2 ---获得国家授权发明专利和实用新型专利 各一项

研究成果3---出版译著一部

研究成果4 ---团队成员学历职称提升

获得2015贵州省科技进步三等奖



获得首届贵州省高等学校科学研究自然科学成果奖

获得贵州省第二届、第四届自然科学优秀学术论文三等奖

国际交流情况---出席 9th Europe EMC & 20th Wroclaw EMC, 2010, Wroclaw, Poland

国际公认的三大国际一流电磁兼容学术会议：(1) IEEE EMC; (2) EMC Europe; (3) APEMC

国际交流---应邀与国际著名EMC专家David Pommerenke 教授讨论电极移动速度效应

国际公认的三大国际一流电磁兼容学术会议：
(1) IEEE EMC; (2) EMC Europe; (3) APEMC

国际交流---2011年9月应邀在美国约克大学做报告

出席 EMC Europe, Sep25-30, 2011, York, UK

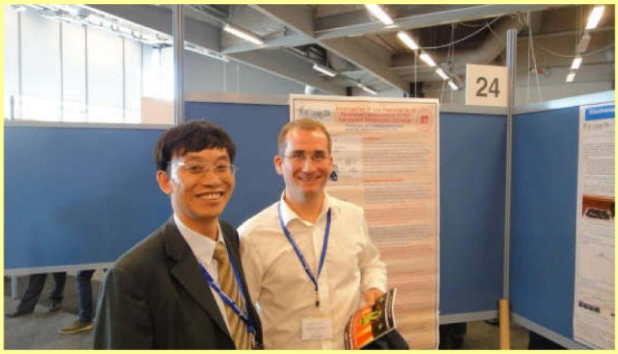
成果的国际影响---国际电磁兼容学会主席 Ghery S. Pettit 博士称赞我们的研究 "Good Work!"

出席 2013APEMC, Melbourne, Australia，May20-25, 2013

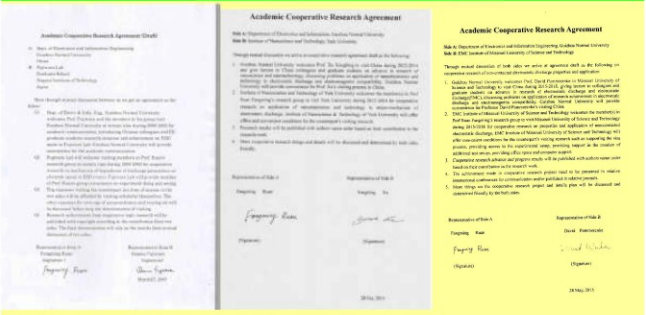
国际交流情况---出席 2013 APEMC, 2013, Melbourne, Australia 的华人学者(部分)

左起：樊俊(密苏里科技大学教授)、阮方鸣(贵州师范大学教授)、谢彦召(西安交通大学教授)、石立华(解放军理工大学教授)、魏兴昌(浙江大学教授)、孟苹(清华大学教授)

在欧洲国际电磁兼容学术会议交流 (2014.09.02, 瑞典 哥德堡)



国际合作和交流—与日本名古屋工业大学、美国约克大学、美国密苏里科技大学签订学术研究合作协议



研究成果的国际影响——

2014国际电过载/静电放电学术会议(2014EOS/ESD Symposium)大会主旨演讲人Robert Ashton博士请求引用我研究成果的邮件

-----原始信息-----
来自: Robert Ashton <Robert.Ashton@onsemi.com>
收件人: "ruan.fm9@gmail.com" <ruan.fm9@gmail.com>
抄送: Robert Ashton <Robert.Ashton@onsemi.com>
已发送: 2014-07-14, 周一, 07:45:34 格林尼治标准时间+0800
主题: Request to Use Figures
Dear Fangming Ruan

I have been asked to give a presentation on System Level ESD at the 2014 EOS/ESD Symposium in Tucson Arizona in September. I plan to discuss your paper "Relationship Investigation of ESD Parameters, Air Pressure Variation and Electrode Approach Speed" from the Journal of Network and Information Security. I would like permission to use Figures 3, 6 and 9 in my presentation to give my audience some insight into your work. The copies of the figures from the PDF document which I have look good enough for my presentation. You do not need to send me copies of the figures.

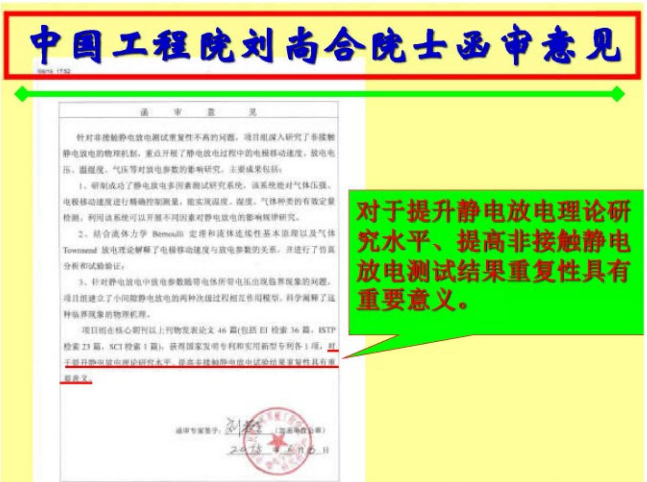
Thank you for your consideration of this.

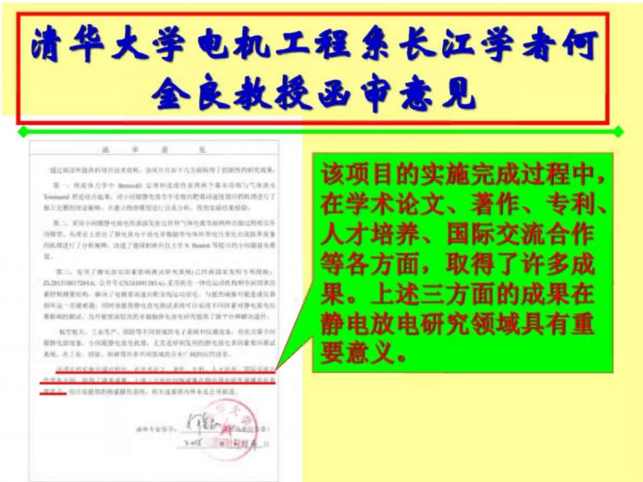
Robert

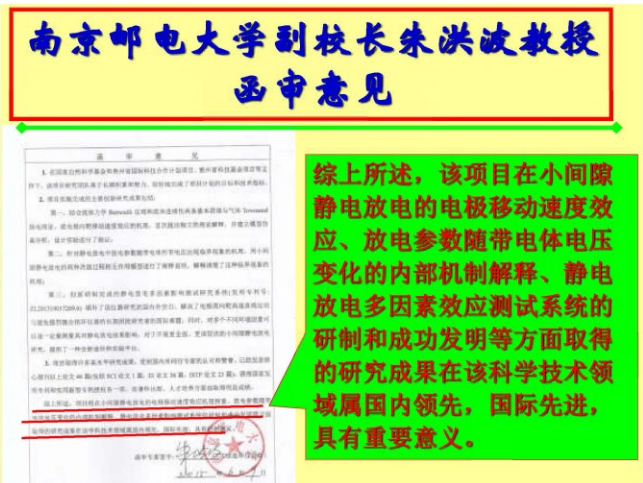
Robert Ashton, Ph.D.
Protection and Compliance Specialist
ON Semiconductor
robert.ashton@onsemi.com
602-244-3924
5005 E. McDowell Rd., Phoenix, AZ 85008
Maildrop: A550

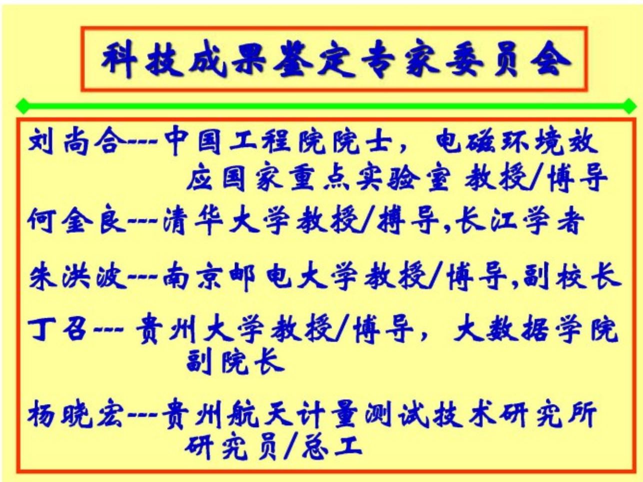

成果的国际影响----印度理工学院学生申请来我们EMC实验室访问研究
Application for Research Internship
顯示詳細資料
寄件者amitsar@iitk.ac.in
收件者ruan200145@yahoo.com
1 個夾檔 491.3KB
儲存至
Dear Dr. Ruan,
I am a III year B.Tech student at Indian Institute of Technology (IIT) Kanpur, India pusuing my majors in Mechanical Engineering.
I read your paper ' Analysis of partial vacuum formation and effect on discharge parameter in short gap ESD ' and found it very interesting and very much in line with my area of interest. Previously, I have done projects on computer simulations of fluid flow and stability of solutions. I am comfortable with HTRI, Flowserve and COMPRESS softwares and also have a good understanding of programming. I am seeking opportunities for a Research Internship from May 2013 to July 2013 and I earnestly wish to work under your guidance .
I request you to consider me for any project that you will be taking up during May-July 2013. I believe that I would enjoy the challenge and the opportunity of learning which would be provided by this position. I would also be benefitted with the invaluable experience that I would gain by working with you. My sincere desire to augment my insight into my field of interest and gain substantial amount of practical knowledge in the field is the sole motivation behind this application.
Please find attached my Resume for further consideration. I would be more than glad to provide any more information that you might need.
Thank you for your time.
Warm regards,
Amit Saraswat
Pre-Final Year Undergraduate
Department of Mechanical Engineering
IIT Kanpur
India
Ph- +91 - 8953 454 277


成果的国际影响---- 2012,2015亚太国际环境电磁学术会议(CEEM)技术程序委员会(TPC)委员证明
CEEM'2012
Executive Committee
General Chairman
Gao Yougang (China)
General Co-Chairmen
Koga R. (Japan)
Zhou Bihua (China)
International Advisory Committee
Co-Chairmen
Nitta S. (Japan) Zhang Lingchang (China)
Members
Fang Dagang (China) Goldblum R. (USA)
Ianoz M. (Switzerland) Liu Shanghe (China)
Qiu Aici (China) Radasky W.A (USA)
Yoshino T. (Japan) Zhang Minggao (China)
Technical Program Committee
Chairman Yang Qianli (China)
Co-Chairmen
Fujiwara O. (Japan) Shi Lihua (China)
Members
Chen Q. (Japan) Chen X.D. (UK)
Chen Z.Y. (China) Fang D.G (China)
Fichte L.O. (Germany) Gao B.Q (China)
Gao Y.G. (China) Gavan J. (Isreal)
Guo G.Z (China) Han F. (USA)
Huang Y. (U.K) Ianoz M. (Switzerland)
Kim J.H. (Korea) Koga R. (Japan)
Koshevaya (Mexico) Kubina S. (Canada)
Liang P. (HK.China) Liu Y.A. (China)
Lu Y.H. (China) Nitta S. (Japan)
Piette M. (Belgium) Rakov V.A. (USA)
Ruan F.M. (China) Shi X.W. (China)
Sokolov S.A (Russia) Song X.T. (China)
Su D.L. (China) Trzaska H. (Poland)
Wang J.Q. (Japan) Xie Y.Z. (China)
Organizaing Committee
Chairman Zhang Y.F. (China)
CEEM'2015
Conference Committees
Executive Committee
International Advisory Committee
Technical Program Committee
Members


中国工程院刘尚合院士函审意见
函审意见
对于提升静电放电理论研究水平、提高非接触静电放电测试结果重复性具有重要意义。


清华大学电机工程系长江学者何金良教授函审意见
函审意见
该项目的实施完成过程中，在学术论文、著作、专利、人才培养、国际交流合作等各方面，取得了许多成果。上述三方面的成果在静电放电研究领域具有重要意义。


南京邮电大学副校长朱洪波教授函审意见
函审意见
综上所述，该项目在小间隙静电放电的电极移动速度效应、放电参数随带电体电压变化的内部机制解释、静电放电多因素效应测试系统的研制和成功发明等方面取得的研究成果在该科学技术领域属国内领先，国际先进，具有重要意义。


科技成果鉴定专家委员会
刘尚合----中国工程院院士，电磁环境效应国家重点实验室 教授/博导
何金良----清华大学教授/博导,长江学者
朱洪波----南京邮电大学教授/博导,副校长
丁召---- 贵州大学教授/博导，大数据学院副院长
杨晓宏----贵州航天计量测试技术研究所研究员/总工

科技成果专家委员会鉴定意见

研究成果的重要意义

- 实现静电放电电极移动速度效应研究理论突破，解决了困扰国际电磁兼容研究领域三十多年的难题，为IEC制定至今尚未制定的非接触静电放电国际标准提供理论技术基础参考。
- 对放电参数随电压变化出现临界现象的研究，提出新了的小间隙静电放电修正模型，是电磁兼容静电放电研究领域的重要推进。
- 研究并成功发明了“多因素静电放电效应测试系统”，为静电放电研究提供崭新平台途径，其产业化有重大科研价值和经济效益前景。

第二部分：

技术研究成果介绍

研究背景—项目来源

项目1：国家自然科学基金面上项目

名称：小间隙放电中电极速度效应机理研究

编号：60971078

项目2：贵州省国际科技合作重点项目

名称：小间隙放电的速度相关性和临界现象机理研究

编号：黔科合G字[2008]700115号

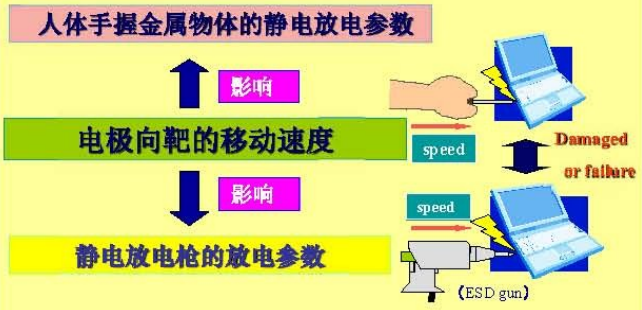
项目3：贵州省科学技术基金

名称：静电放电参数与电极速度依赖关系的机理研究

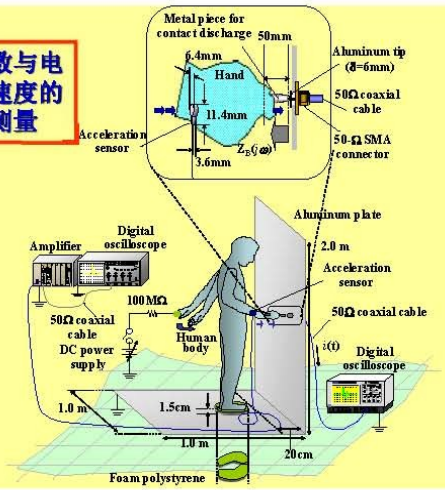
编号：黔科合J字[2007]2211号

- 引言
- 人体静电放电的实验结果
- 不同电压时的电极速度效应
- 电极速度效应的临界现象
- 电极速度效应的机理分析
- 实验测试系统的研制和验证
- 人体生物电阻抗的算法
- 结语

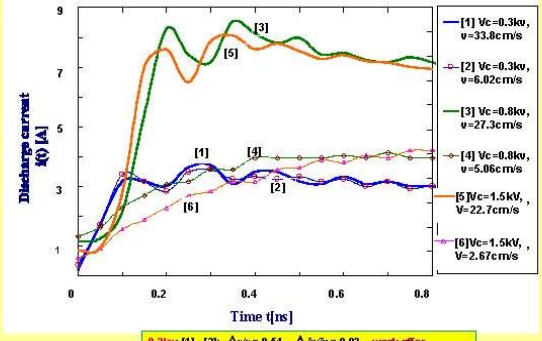
引 言



放电参数与电极运动速度的同步测量

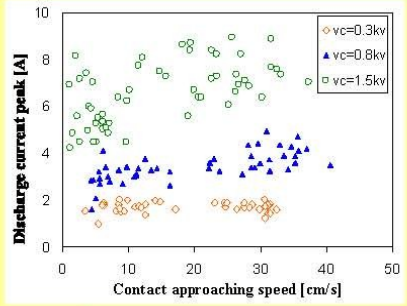


在不同电压和速度下的放电电流波形



0.3kv: [1] - [2]: Δv/v = 8.51, Δip/ip = 0.03, weak effec
0.8kv: [3] - [4]: Δv/v = 5.35, Δip/ip = 1.07, strong effect
1.5kv: [5] - [6]: Δv/v = 10.86, Δip/ip = 0.99, strong effect

电极移动速度对放电电流峰值的影响

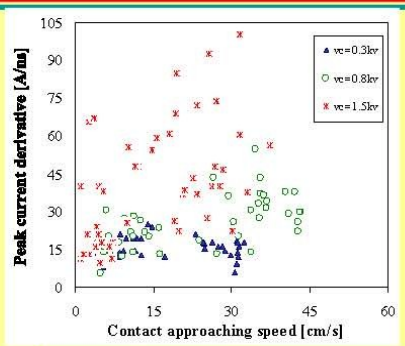


Charge voltage (kV)	Correlation coefficient
0.3	0.029
0.8	0.668
1.5	0.612

SPSS: Statistical Package for Social Science

电极速度与放电参数相关性的统计分析

电极移动速度对峰值电流导数的影响

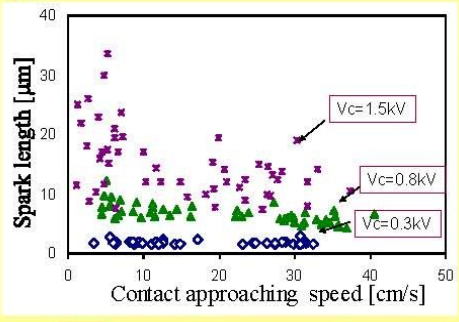


Charge voltage (kV)	Correlation coefficient
0.3	-0.022
0.8	0.644
1.5	0.522

SPSS: Statistical Package for Social Science

在相同电压下, 电极速度越快, 电流导数的峰值也越高

电极移动速度对放电弧长的影响



Charge voltage (kV)	Correlation coefficient
0.3	-0.028
0.8	-0.656
1.5	-0.482

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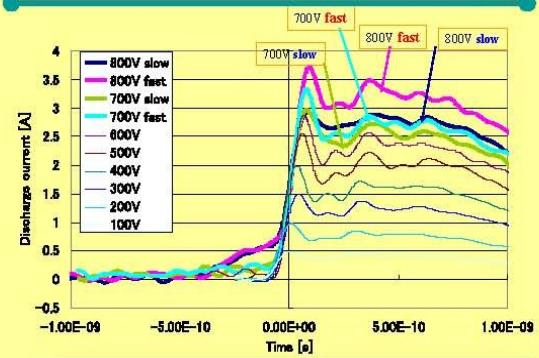
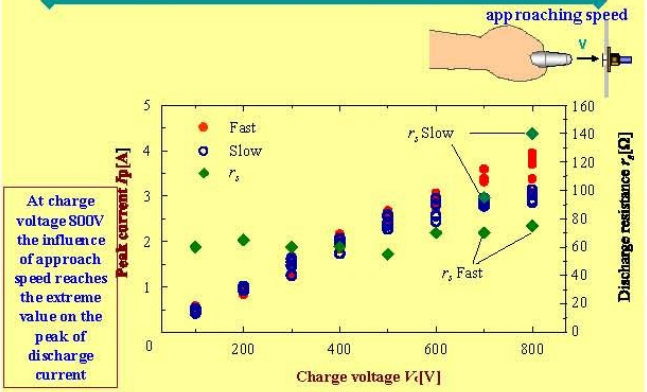
在相同电压下, 电极运动速度越快, 放电弧长越短

在电极速度影响下的放电电流波形

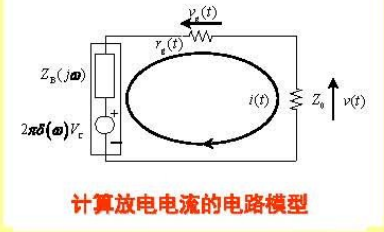


At charge voltage 800V the influence of approach speed reaches the extreme value on the peak of discharge current

电极速度的影响在电压为800V时达到极值



带电体电压对放电参数的影响



计算放电电流的电路模型

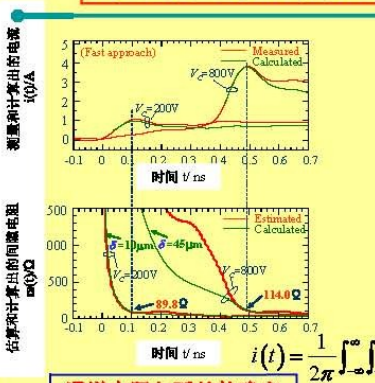
Ramp-Weizel 公式

$$r(t)=\frac{d}{\sqrt{\frac{2\alpha}{p}\int i^2(\tau)d\tau}}$$

$$v_g(t)=r_g(t)i(t)$$

$$=V_c-\frac{1}{2\pi}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\{Z_0+Z_B(j\omega)\}\cdot i(\tau)\cdot e^{j\omega(t-\tau)}d\tau d\omega$$

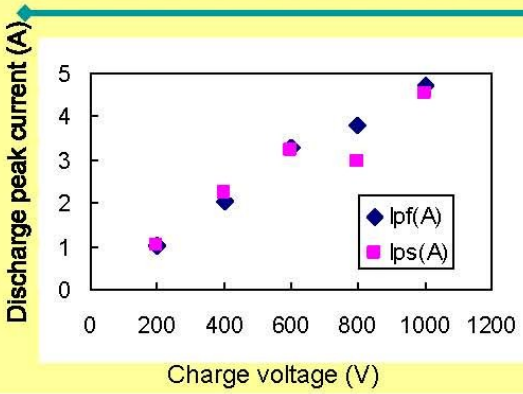
带电体电压对放电参数的影响



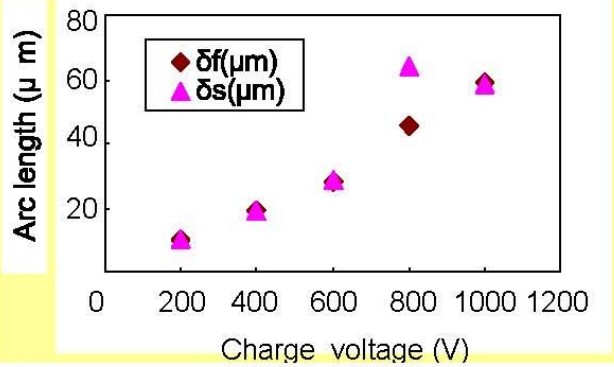
$$i(t)=\frac{1}{2\pi}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\frac{V_c-v_g(\tau)}{Z_0+Z_B(j\omega)}\cdot e^{j\omega(t-\tau)}d\tau d\omega.$$

通道电阻与弧长的确定

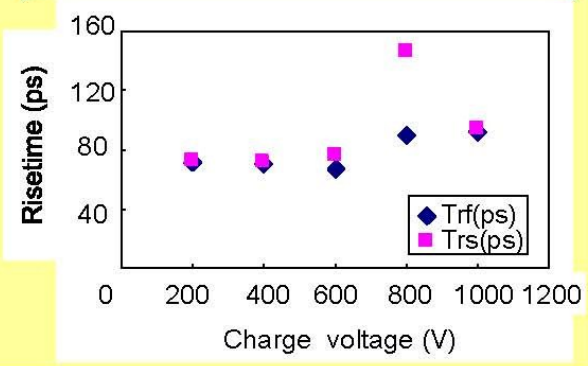
不同电压下电极速度对电流峰值的影响



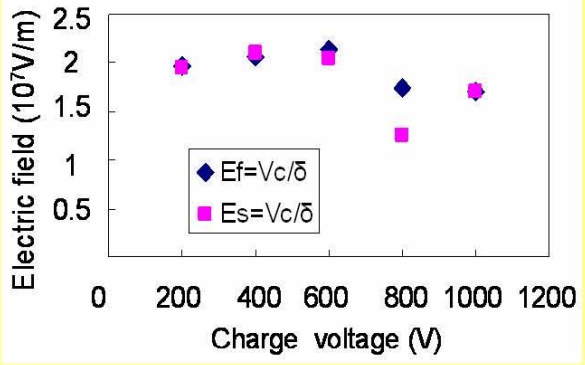
不同电压下电极速度对弧长的影响



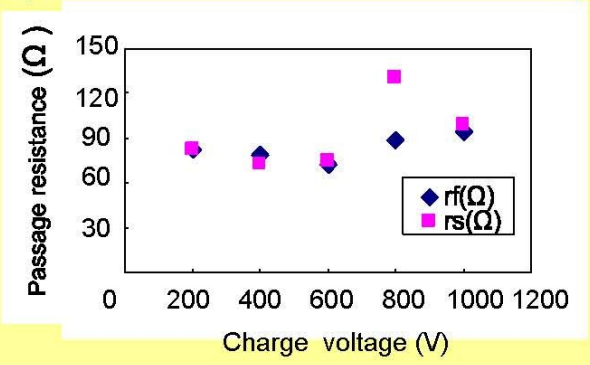
不同电压下电极速度对上升时间的影响



电压和电极移动速度对电场强度的影响



不同电压和电极速度对间隙电阻的影响



在不同电压和速度下的放电参数

- 在带电电压为0.3kV时，放电参数与电极运动速度几乎没有关系。
- 在带电电压为 0.8kV时 电极运动速度对放电电流峰值的影响非常明显。
- 带电电压为1.5kV 时，电极运动速度对放电参数的影响大于Vc=0.3kV时的影响而小于Vc=0.8kV的影响。

放电电流参数与电极运动速度的相关系数及统计分析

Table 1 Correlation coefficients with contact moving speed for different charge voltages

V_C [kV]	Correlation coefficients					
	Current peak		Max Rising slope		Spark length	
0.3	0.029	NS	-0.022	NS	-0.028	NS
0.5	0.544	**	0.452	**	-0.532	**
0.8	0.668	**	0.644	**	-0.656	**
1.0	0.572	**	0.511	**	-0.516	**
1.1	0.555	**	0.557	**	-0.338	*
1.5	0.612	**	0.522	**	-0.482	**

NS --- no significant correlation; * --- $p < 0.05$ ** --- $p < 0.01$

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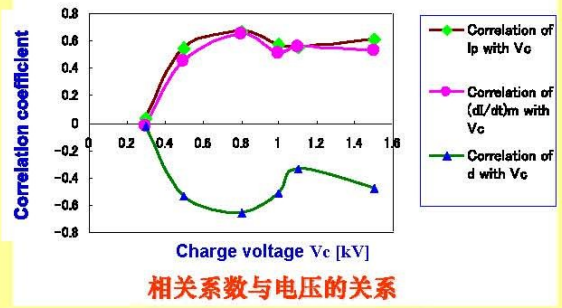
电极速度效应随电压变化临界现象分析



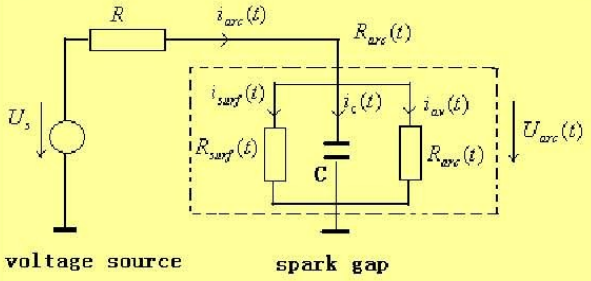
相关系数与电压的关系

电极速度效应随电压变化临界现象分析

表 5-1 小间隙放电的三类参数设置范围

参数范围	1	2	3
放电间隙(μm)	<10	20-80	80-100
上升时间(ps)	<40	300-600	<350
击穿电压(V)	<700	700-2000	>1500
场强(kV/mm)	>50-100	25-75	<8-35
放电波形	无台阶	有台阶	无台阶
阴极影响	有	无	无
阳极影响	无	有	有
气压影响	无	有	有
所属过程	表面	表面和宫期	宫期

电极速度效应随电压变化临界现象分析



小间隙静电放电模型的分析

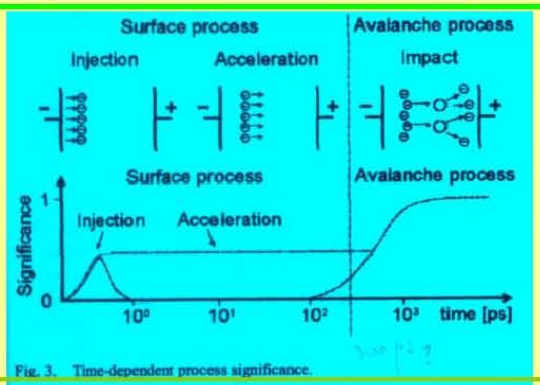
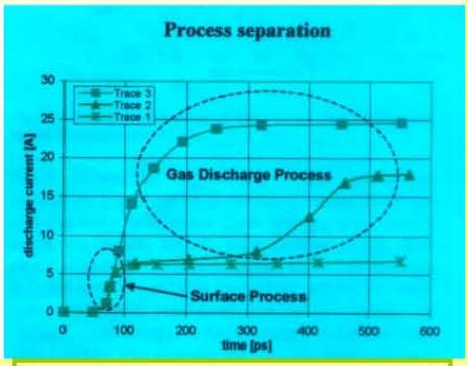


Fig. 3. Time-dependent process significance.

Short-gap Electrostatic Discharge Model

用小间隙静电放电模型的分析

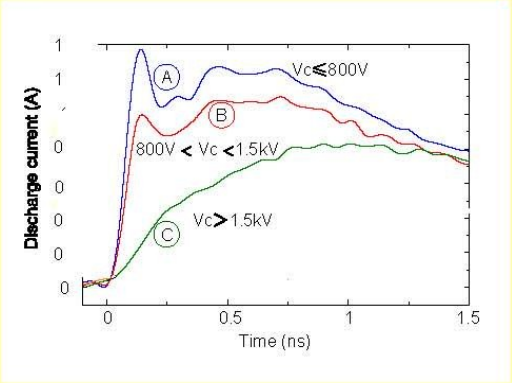


Short-gap Electrostatic Discharge Model

电极速度效应随电压变化临界现象分析

出现临界现象的原因在于：800V的电压是表面过程向气体电子雪崩过程转变的关键点。在这个点附近，表面过程和电子雪崩过程同时起作用。电压低于800V，放电过程的特性主要由表面过程决定；电压高于800V，表面过程影响下降，放电过程则主要由电子雪崩过程所决定。这样，就造成了在800V时，电极的快速移动速度所产生的特殊的临界现象。

在不同电压影响下的放电电流波形分类



电极速度效应随电压变化临界现象分析

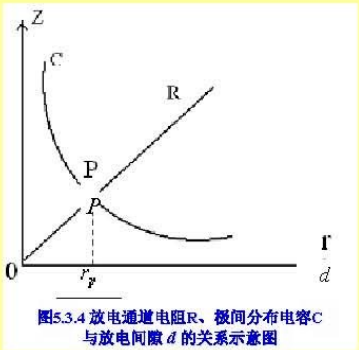
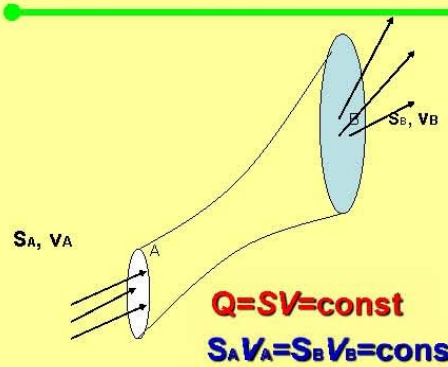


图5.3.4 放电通道电阻R、极间分布电容C与放电间隙 d 的关系示意图

电极移动速度效应的机理分析—结合流体力学原理

作为一种流体，空气运动遵循流体力学的基本原理和规律。应用流体力学中的连续性原理和Bernoulli定理，分析放电间隙内部压强与间隙外部压强，在电极移动速度下所产生的差别，可以从理论上给出一种对放电参数电极移动速度效应产生机理新的解释。

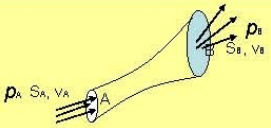
流体力学的基本原理---连续性方程



$Q=SV=const$

$S_AV_A=S_BV_B=const$

流体力学的基本原理---Bernoulli 方程

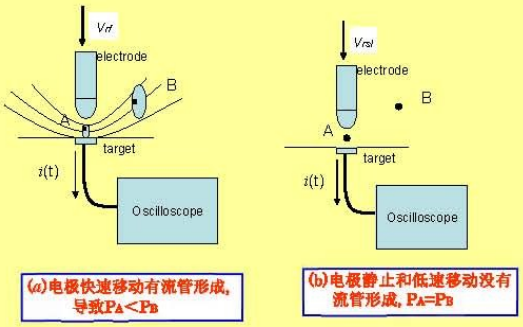


$$p_B - p_A = \frac{1}{2}\rho(v_A^2 - v_B^2) + \rho g(h_A - h_B)$$

$$p_B + \rho g h_B + \frac{1}{2}\rho v_B^2 = p_A + \rho g h_A + \frac{1}{2}\rho v_A^2$$

$$p + \rho g y + \frac{1}{2}\rho v^2 = const.$$

电极移动速度效应的机理分析



(a)电极快速移动有流管形成，导致$P_A<P_B$

(b)电极静止和低速移动没有流管形成，$P_A=P_B$

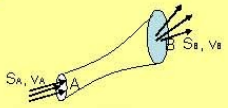
电极移动速度效应的机理分析

$$p_A = p_B - \frac{1}{2}\rho\left[\left(\frac{S_B}{S_A}\right)^2 - 1\right]v_B^2$$

$$\left[\left(\frac{S_B}{S_A}\right)^2 - 1\right] > 0$$

$$p_A < p_B$$

电极移动速度效应的机理分析

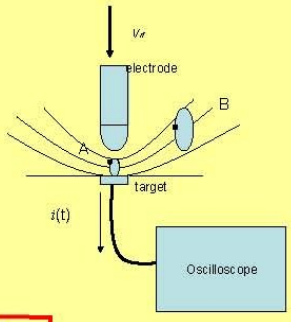


$S_AV_A=S_BV_B=const$

$$i = i_0 e^{\alpha d}$$

$$\frac{\alpha}{P} = A\exp\left(\frac{-B}{E/P}\right)$$

Townsend 放电理论



电极移动速度效应机理的数值分析

在小间隙放电模型中，电子的迁移速度v_e与气体压强p有密切关系

$$i(t)_{av} = C\frac{dV}{dt} + eN_0\frac{v_e}{d}\exp\left(\int_0^t \alpha(\xi)v_e(\xi)d\xi\right) \quad (3.2.15)$$

$$i(t)_{surf} = \frac{4}{9}\varepsilon_0\sqrt{\frac{2e}{m_e}}\cdot\frac{S_n(t)\cdot V(t)^{\frac{3}{2}}}{\left(d - v_e(t)\cdot t\right)^2}K[\alpha(t)] \quad (3.2.19)$$

$$\alpha = Ap\exp\left(-\frac{Bp}{E}\right)$$

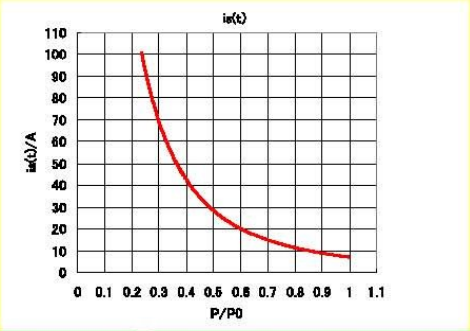
电极移动速度效应机理的数值分析

$$v_e(t) = C\cdot\left(\frac{E}{p}\right)^{\frac{1}{2}}$$

$$C = 3.3\times10^6\ \frac{cm^{3/2}torr^{1/2}}{sV^{1/2}}$$

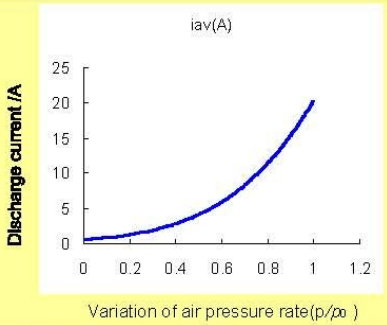
依据上面各式和已知相关参数，可以初步估算在气体压强变化影响下，放电电流的变化情况，结果如下面两个图所示

电极速度效应机理的数值分析



随着气体压强的减小，表面过程中的放电电流迅速增加

电极速度效应机理的数值分析



随着气体压强的减小，气体电子雪崩过程中的放电电流迅速减小

电极速度效应机理的数值分析

考虑电极移动速度改变放电间隙内压强，同时改变两电极间电容大小进而改变两极间电场强度，可以由极间电容表达式

$$C = \frac{S}{4\pi kd} \quad (4.3.14)$$

出发，结合(4.3.11), (4.3.12)和小间隙静电放电模型的有关参量，可以推得放电电流表达式为：

$$i(t) = \frac{dQ(t)}{dt} = i_0\exp\left[\left(d_0 - V_h t\right)AP\exp\left(\frac{-BpS}{4\pi kQ(t)}\right)\right] \quad (4.3.15)$$

电极速度效应机理的数值分析

$$i(t) = \frac{dQ}{dt} = i_0\exp\left[\begin{array}{l}(d_0 - V_h t)A\left(p_B - \frac{1}{2}\rho\left(1-\left(\frac{1}{100}\right)^2\right)V_h^2\right)\bullet \\ \bullet\exp\left(\frac{-\left(p_B - \frac{1}{2}\rho\left(1-\left(\frac{1}{100}\right)^2\right)V_h^2\right)BS}{4\pi kQ(t)}\right)\end{array}\right]$$

电极移动速度效应机理的数值分析

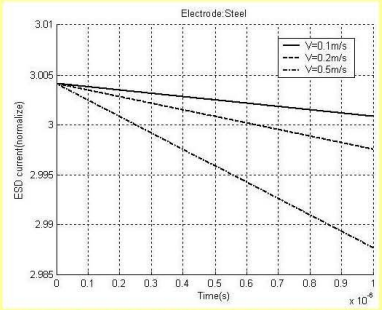
$$\frac{dQ}{dt}=\exp\left[\begin{array}{l}(10^{-4}-V_h t)A\left(10^5-0.65^2V_h^2\right)\cdot \\ \cdot\exp\left(\dfrac{-\left(10^5-0.65^2V_h^2\right)B\times 0.035\times 10^{-13}}{Q(t)}\right)\end{array}\right]$$

$d_0=10^{-4}m$ $V_h=0.1m/s,0.2m/s,0.5m/s$ $p_B=10^5$ Pa,

$\rho=1.293\mathrm{kg/m^3}$ $S=4\times10^{-6}m^2$ $\varepsilon=\frac{1}{36\pi}\times10^{-9}F/m$

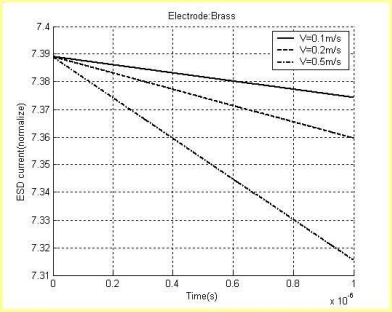
$k=8.9\times10^9$ $\mathrm{Nm^2/C^2}$

电极移动速度效应机理的数值分析



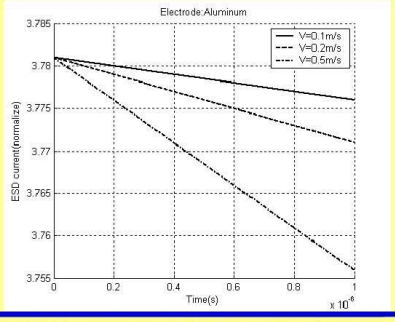
电极移动速度对放电电流的影响（不锈钢电极）

电极移动速度效应机理的数值分析



电极移动速度对放电电流的影响（铜电极）

电极移动速度效应机理的数值分析



电极移动速度对放电电流的影响（铝电极）

电极移动速度效应机理的实验验证

创新特点：(1) 实现放电枪真实的全直线运动，可高速向靶运动放电无损坏；

(2) 全封闭箱体，不同因素精确控制 (该系统已申请国家专利保护！)

电极移动速度效应机理的实验验证

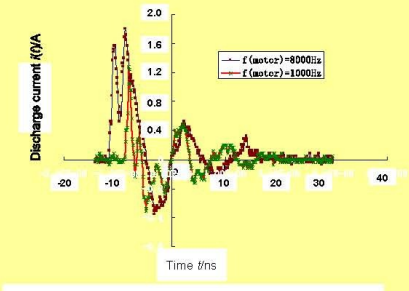


Fig5 Comparison of two electrode speeds in ESD events

电极移动速度效应机理的实验验证

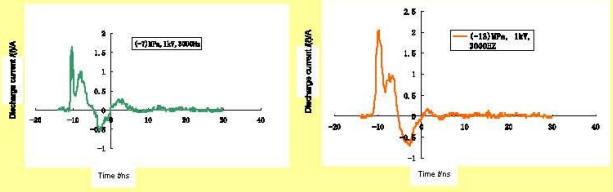
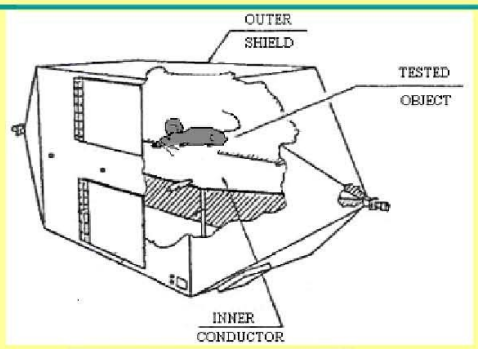


Fig7 Discharge current with comparatively high gas pressure in ESD

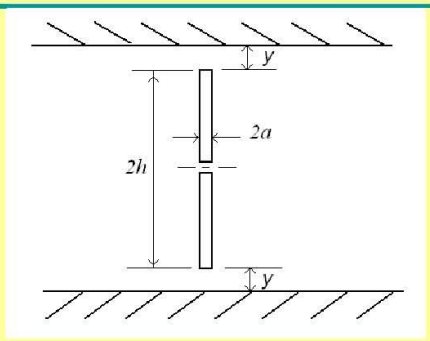
Fig8 Discharge current with comparatively low gas pressure in ESD

计算人体生物电阻抗的算法



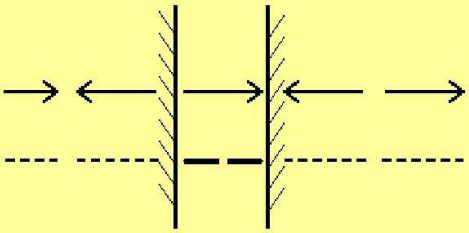
电磁波辐射系统结构示意图

计算人体生物电阻抗的算法



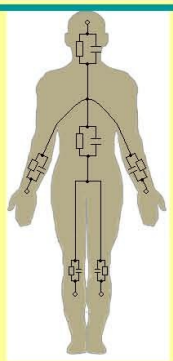
校正天线的设置

计算人体生物电阻抗的算法



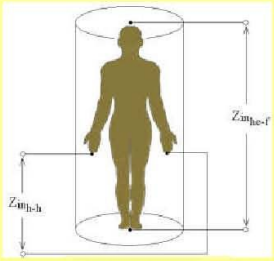
电磁波的镜像反射效应

计算人体生物电阻抗的算法

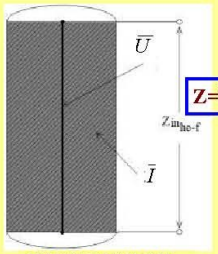


人体的等效电路

计算人体生物电阻抗的算法



输入输出端子的选择

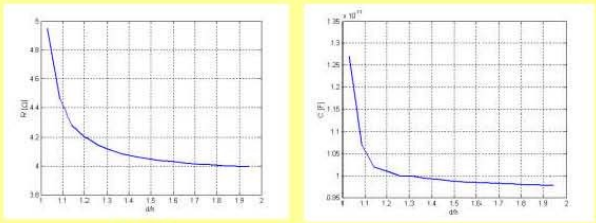


$Z=\bar{U}/\bar{I}$

计算输入阻抗的方法

用人体的柱体模型计算阻抗

计算人体生物电阻抗的算法



(a) 电阻　　(b) 电容

置于横电磁波小室中柱体模型的计算结果

结　语

小间隙静电放电在军事武器、航空航天飞行器，以及工业生产中是普遍存在的。分析研究小间隙静电放电各种特殊性质的机理，如放电参数随放电体与受电体(即电极)间机械运动速度变化的机理，电压导致放电参数出现临界现象的机理，多因素作用下静电放电参数的变化规律等，有着重要的理论意义和实际的应用价值。基于已经取得的研究成果，进一步进行深入和拓展的研究，取得新的进展和成就，为非接触静电放电国际标准的提出建立提供理论和技术参考依据。

谢谢大家！

Investigation of Electrode Moving Speed Effect in Electrostatic Discharge Involved in Standard on Non-Contact ESD

Ruan Fangming

Guizhou Normal University

Preface

Electrostatic Discharge (ESD) is serious threat of various electronic system and instrument in aerospace and astronomic, industry, and defence. International Electrotechnical Commission has made test standards of contact ESD, but till now no standards made for non-contact ESD which taken with large amount place in reality situation. .

Mechanism and relative properties investigation of electrode moving speed effect in short-gap ESD may have strong benefit effect on deeply understanding non-contact ESD, providing important and key technical and theoretical support to proposal of non-contact ESD test standards and protection from ESD harm.

EMC team of Guizhou Normal University, supported by National Nature Science Foundation of China, by Guizhou Province Key Project for International Cooperation of Science and Technology, and by Nature Science and Technology Foundation of Guizhou, proposed based on many years research effort theoretical model and given experiment verification of electrode moving speed effect on discharge parameters, solved two difficult problems perplexed researchers in various countries for more than thirty years, made almost breakthrough and creative advancement in the expertise of non-contact ESD research.

Outline

- Back Ground
- Research Content
- Creativity of Research
- Achievement of Research
- Significance of Achievement
- International Influence

Back Ground

- Losses Caused by ESD:

USD 50,000,000,000 / Year

IEC CCC IEEE →

Test Standard of ESD?

Non-Contact ESD ?-- No !

Contact ESD --- Yes

Effect on Parameters of Electrode Moving speed in Electrostatic Discharge / 1987

Phenomenon: First Discussed by B Daout H Ryser etc In Switzerland Federal Institute of Tech

Distinctive Variation of Parameters in Human-Metal ESD

Strong Impact on

Velocity of Electrode to Target

speed

Serious threat in vain

Strong Impact on

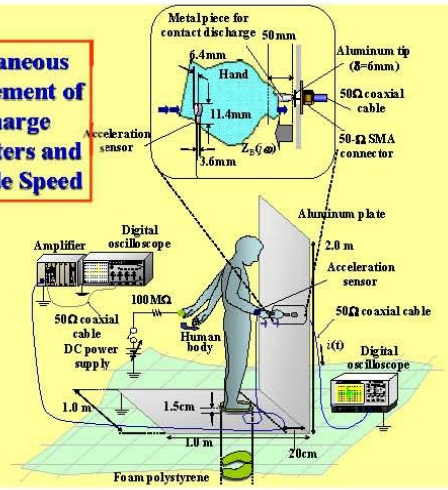
speed

Discharge Parameters of ESD Gun

(ESD gun)

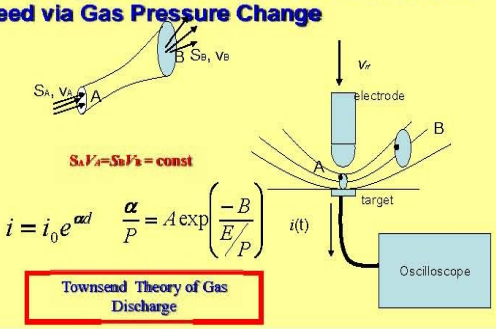
Mechanism: ?

Simultaneous Measurement of Discharge Parameters and Electrode Speed



Creativity

1. Proposed Clear Model First in the World Describing Effect on Parameters of Electrode Speed via Gas Pressure Change



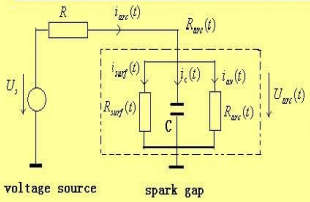
$S_A V_A = S_B V_B = \text{const}$

$$i = i_0 e^{\alpha d} \qquad \frac{\alpha}{P} = A \exp\left(\frac{-B}{E/P}\right)$$

Townsend Theory of Gas Discharge

Creativity

2. Discovering Phenomenon of Parameters Threshold Resulted from Charge Voltage Change, and Giving Theoretic Illustration on the Mechanism, Revised and Made Performance of Short-gap ESD Model



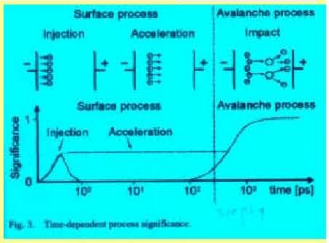


Fig. 3. Time-dependent process significance.

Creativity

3. Invented a New System for Research of Multi Factor Effect on Discharge Parameters, Providing Solution to Important Two Difficult Problems in ESD Expertise

Hints: (1) Realization of Real Time Motion without Damage of Instrument when Moving Electrode at Large Velocity to Target

(2) Perform Sealed Box Making Possible Effective Control of Various Factor Impacting on Discharge Parameters (Chinese Patent No. : ZL201310017269.6)

Comparance1: ESD Research Setup by David Pommerenke Missouri Univ of Sci. & Tech.(1995)

40 *D. Pommerenke/Journal of Electrostatics 36 (1995) 31–54*

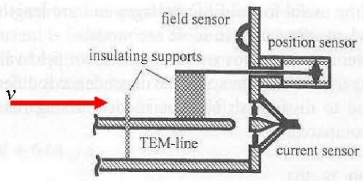


Fig. 7. Set-up for the measurement of arc length, speed of approach and discharge current.

Weakness: (1) Large velocity of electrode may lead to damage of instrument

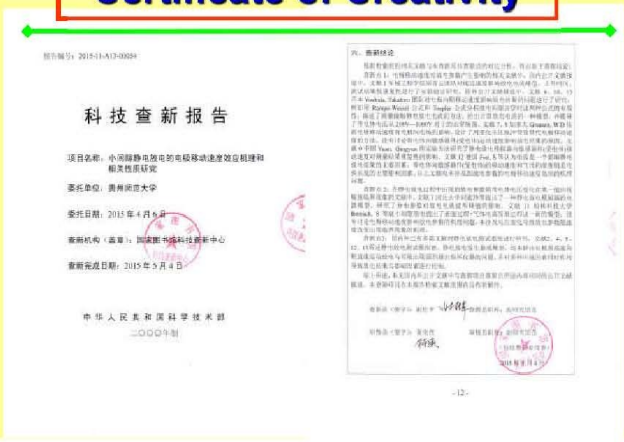
(2) Different factors can not be controlled effectively due to open Surroundings

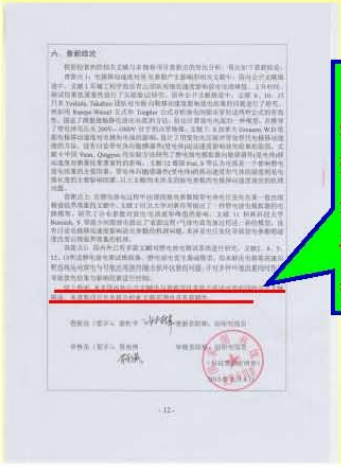
Comparing 2: Research Setup used by State Key Lab of Electromagnetic Circumstance Effect (2012.11.12)

Weakness: (1) Non-Straight Line Motion; (2) Control Difficulty of Various Factors in Open Circumstances

Source: Report in The First ESD Protection and Standardization Forum, 2012 Beijing

Certificate of Creativity



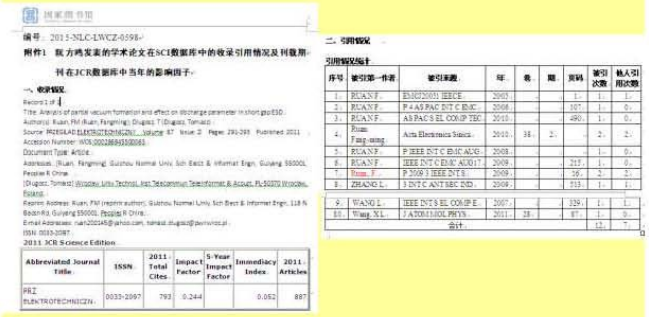


综上所述，未见国内外公开文献中与查新项目查新点所述内容相同的公开文献报道，本查新项目在本报告检索文献范围内具有新颖性。

Research Achievement 1—Academic Papers Publication

截止2013年6月，已发表高水平学术论文46篇，其中三大检索论文EI(36)、ISTP(21)、SCI(1)篇

Research Achievement 1—Citation by Famous Journals



Certificate of Research Achievement —Report on Papers Indexed

检 索 报 告

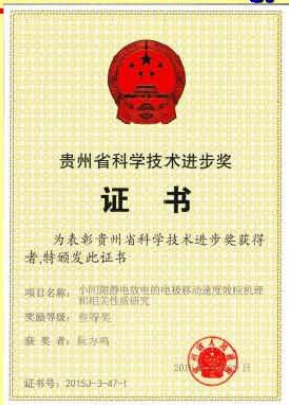
阮方鸣发表的学术论文被SCI数据库收录1篇，附刊载期刊当年影响因子；在SCI数据库中被引用12次，其中他人引用7次；被EI数据库收录39篇；被CPCI-S数据库收录23篇；在CNKI-CCD数据库被引用64次，其中他人引用36次，详见附件1-4。

Achievement 2 --- Awarded Two Chinese Patents

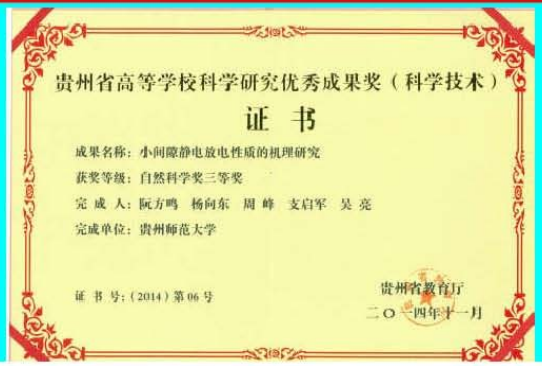
Achievement 3---Translation of A Work

Achievement 4 --- Degree Upgrading of Research Group Members

Obtained 2015 Guizhou Province Prize of Nature Science and Technology Achievement



Obtained Guizhou Province Education Department Third Prize of Nature Science Achievement



Obtained the Third Grade Prize of Excellent Nature Science Paper in the 2nd & the 4th Guizhou Province Contest

International Communication --- Attending 9th Europe EMC & 20th Wroclaw EMC, 2010, Wroclaw, Poland

Discussion with Prof David Pommerenke from Missouri U of S&T when Attending IEEE EMC 2009

Given A Speak at York University when Attending EMC Europe 2011, Sep25-30, 2011, York, UK

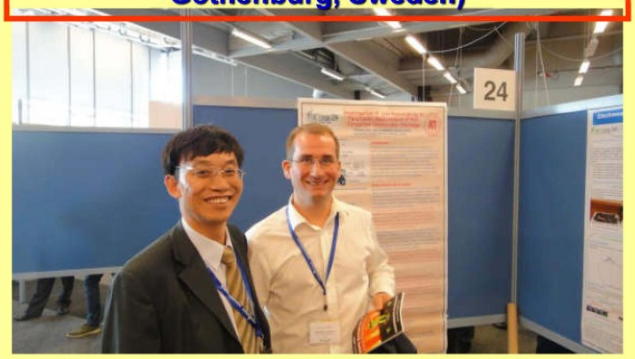
"Good Work!" Praised by Dr Ghery S. Pettit---President of EMC Commission of IEEE

Attending 2013APEMC, Melbourne, Australia, May 20-25, 2013

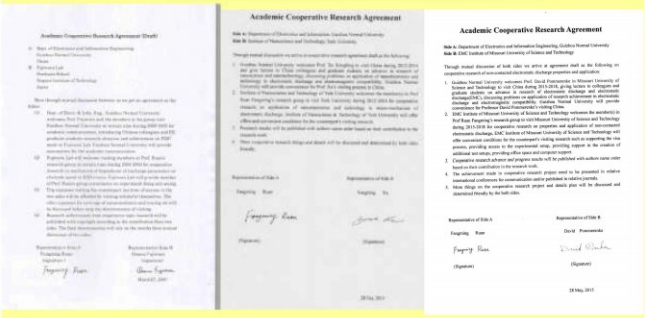
Chinese Scholars (part) Attending APEMC, 2013, Melbourne, Australia

Starting from Left: Dr Jun Fan (Missouri Univ. of S&T)、Prof Fangming Ruan(Guizhou Normal Univ.)、Prof Yanzhao Xie(Xi'an Jiaotong Univ.)、Prof Lihua Shi(PLA Univ of S&T)、Dr Xingchang Wei(Zhejiang Univ)、Prof Cui Meng(Tsinghua Univ)

International Communication--- Attending EMC Europe 2014 (2014.09.02, Gothenburg, Sweden)



International Cooperative Agreements with NIT(Japan), York University (UK), and Missouri U of S & T (US)



International Influence ---- A Letter from Conference Speaker 2014 EOS & ESD, Request Admission of Citing My Team Research Achievement

原始信息
来自: Robert Ashton <Robert.Ashton@onsemi.com>
收件人: "ruan.fm9@gmail.com" <ruan.fm9@gmail.com>
抄送: Robert Ashton <Robert.Ashton@onsemi.com>
已发送: 2014-07-14, 周一, 07:45:34 格林尼治标准时间+0800
主题: Request to Use Figures

Dear Fangming Ruan

I have been asked to give a presentation on System Level ESD at the 2014 EOS/ESD Symposium in Tucson Arizona in September. I plan to discuss your paper "Relationship Investigation of ESD Parameters, Air Pressure Variation and Electrode Approach Speed" from the Journal of Network and Information Security. I would like permission to use Figures 3, 6 and 9 in my presentation to give my audience some insight into your work. The copies of the figures from the PDF document which I have look good enough for my presentation. You do not need to send me copies of the figures.

Thank you for your consideration of this.

Robert

Robert Ashton, Ph.D.
Protection and Compliance Specialist
ON Semiconductor
robert.ashton@onsemi.com
602-244-3924
5005 E. McDowell Rd., Phoenix, AZ 85008
Maildrop: A550

International Influence---- Application from A Student of India Institute of Technology, Requested to be A Visiting Researcher in My Lab

Application for Research Internship f
顯示詳細資料
寄件者amitsar@iitk.ac.in
收件者ruan200145@yahoo.com
1 個夾檔 491.3KB
歡在至
Dear Dr. Ruan,
I am a III year B.Tech student at Indian Institute of Technology (IIT) Kanpur, India pusuing my majors in Mechanical Engineering.
I read your paper ' Analysis of partial vacuum formation and effect on discharge parameter in short gap ESD ' and found it very interesting and very much in line with my area of interest. Previously, I have done projects on computer simulations of fluid flow and stability of solutions. I am comfortable with HTRI, Flowserve and COMPRESS softwares and also have a good understanding of programming. I am seeking opportunities for a Research Internship from May 2013 to July 2013 and I earnestly wish to work under your guidance .

I request you to consider me for any project that you will be taking up during May -July 2013. I believe that I would enjoy the challenge and the opportunity of learning which would be provided by this position. I would also be benefitted with the invaluable experience that I would gain by working with you. My sincere desire to augment my insight into my field of interest and gain substantial amount of practical knowledge in the field is the sole motivation behind this application.

Please find attached my Resume for further consideration. I would be more than glad to provide any more information that you might need.

Thank you for your time.

Warm regards,
Amit Saraswat
Pre-Final Year Undergraduate
Department of Mechanical Engineering
IIT Kanpur
India
Ph- +91 - 8953 464 277

International Influence ---- TPC Membership Certificate of 2012,2015 Asia-Pacific Conference on Environment Electromagnetics(CEEM)

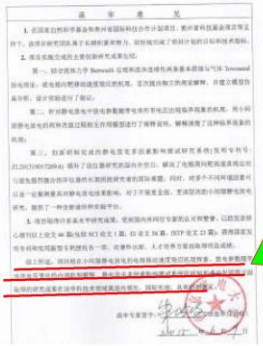
Comments from Academician Shanghe Liu of China Academy of Engineering

对于提升静电放电理论研究水平、提高非接触静电放电测试结果重复性具有重要意义。

Comments from Prof Jinliang He in Tsinghua University

该项目的实施完成过程中，在学术论文、著作、专利、人才培养、国际交流合作等各方面，取得了许多成果。上述三方面的成果在静电放电研究领域具有重要意义。

Comments from Prof Hongbo Zhu in Nanjing University of Post & Communication



综上所述，该项目在小间隙静电放电的电极移动速度效应、放电参数随带电体电压变化的内部机制解释、静电放电多因素效应测试系统的研制和成功发明等方面取得的研究成果在该科学技术领域属国内领先，国际先进，具有重要意义。

Commission Evaluating Achievement of Science and Technology

刘尚合---中国工程院院士，电磁环境效应国家重点实验室 教授/博导

何金良---清华大学教授/博导,长江学者

朱洪波---南京邮电大学教授/博导,副校长

丁召--- 贵州大学教授/博导，大数据学院副院长

杨晓宏---贵州航天计量测试技术研究所研究员/总工

Final Official Comments of Experts Commission

Significance of Research Achievement

- Realization of Theoretical Model Breakthrough to Describing Effect of Electrode Moving Speed to Target; proposing solution of difficult problem disturbing international researchers for more than 30years since 1980's last century; providing theoretical and technological reference to making international test standard of non-contacted electrostatic discharge.
- Discovering Threshold Phenomenon of Discharge Parameters Relying on Variation of Electrode Moving Speed with Charge Voltage Change. A New Model Was Proposed to Explain Mechanism of Threshold Phenomenon and hence Revised Short-gap ESD Model, Shown Distinct Development to ESD Research.
- Researched and Invented Successfully Measurement System of Multiple Factor Effect on Discharge Parameters in ESD Process. Providing a New Platform and Path to Research of Non-contacted ESD, Production of which Refer to Large Amount of Economy Values.

Section Two:

Research Content and Advancement of Technology

Back Ground --- Project Source

Project 1: National Nature Science Foundation of China
Name: Mechanism Investigation of Electrode Moving Speed Effect in Short-gap ESD
No. 60971078
Project 2: Guizhou Province Key Project Supporting International Cooperation Research of Science and Technology
Name: Investigation of Speed Correlation and Threshold Phenomenon Mechanism in Short-gap ESD
No. G [2008]700115
Project 3: Guizhou Province Fund of Science and Technology
Name: Relationship Investigation of ESD Parameters Relying on Electrode Moving Speed
No. J [2007]2211

Outline

- Introduction
- Experiment Result of ESD from Human Body
- Electrode Speed Effect at Various Charge Voltage
- Threshold Phenomenon of Electrode Speed Effect
- Mechanism Analysis of Electrode Speed Effect
- Research of New ESD Measurement System and Verification of Theory
- Algorithm of Human Body Impedance
- Conclusion

Background / 1987

Phenomenon: First Discussed by B Daout H Ryser etc In Switzerland Federal Institute of Tech

Distinctive Variation of Parameters in Human-Metal ESD

Strong Impact on

Velocity of Electrode to Target

speed

Serious threat in vain

Strong Impact on

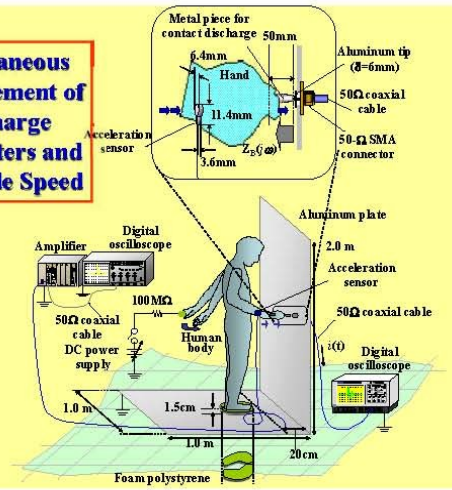
speed

Discharge Parameters of ESD Gun

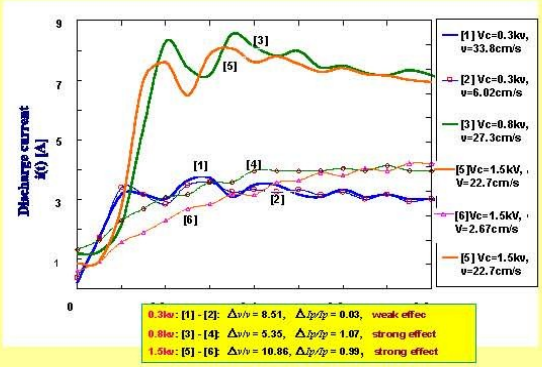
(ESD gun)

Mechanism: ?

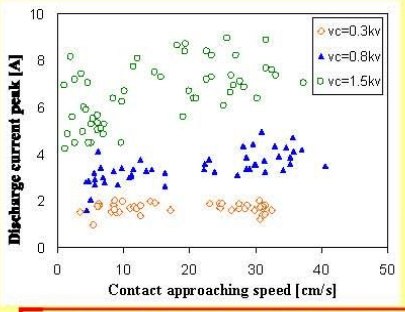
Simultaneous Measurement of Discharge Parameters and Electrode Speed



Discharge Current at different Charge Voltage and Different Electrode Moving Speed



Peak Value of Discharge Value at Different Electrode Moving Speed

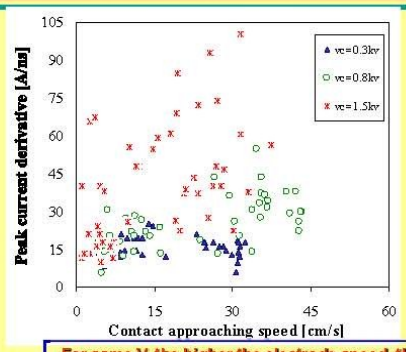


Charge voltage (kV)	Correlation coefficient
0.3	0.029
0.8	0.668
1.5	0.612

SPSS: Statistical Package for Social Science

Statistic Analysis of Correlation of Discharge Parameters with Electrode Moving Speed

Discharge Current Derivative Peaks Affected by Electrode Moving Speed

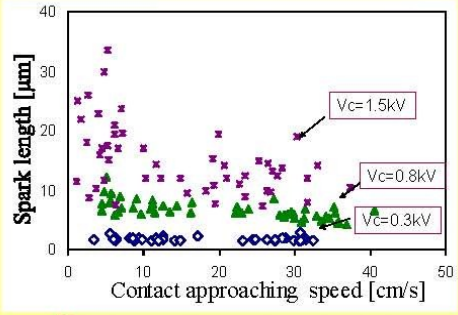


Charge voltage (kV)	Correlation coefficient
0.3	-0.022
0.8	0.644
1.5	0.522

SPSS: Statistical Package for Social Science

For same V, the higher the electrode speed, the larger the peak of current derivative

Electrode Moving Speed Effect on Spark Length

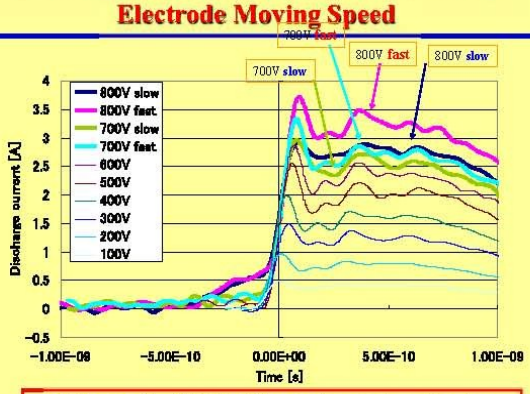


Charge voltage (kV)	Correlation coefficient
0.3	-0.028
0.8	-0.656
1.5	-0.482

SPSS: Statistical Package for Social Science

The Faster the Electrode Moving Speed, the Shorter the Spark Length for identical Charge Voltage

Discharge Current Waveforms Affected by Electrode Moving Speed



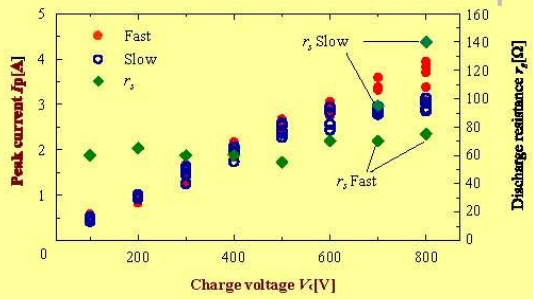
At charge voltage 800V the influence of approach speed reaches the extreme value on the peak of discharge current

Effect of Electrode Moving Speed

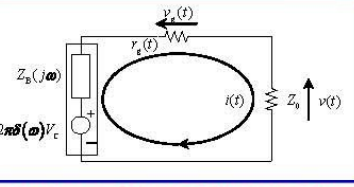
Reaches Maximum at V=800V

approaching speed v

At charge voltage 800V the influence of approach speed reaches the extreme value on the peak of discharge current



Influence of Charge Voltage on Discharge Parameters



Model Used to Calculate Discharge Current

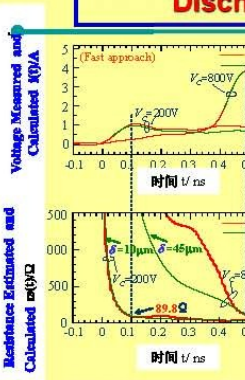
Ramp-Weizel Formular

$$r(t)=\frac{d}{\sqrt{\frac{2\alpha}{p}\int i^2(\tau)d\tau}}$$

$$v_g(t)=r_g(t)i(t)$$

$$=V_c-\frac{1}{2\pi}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\{Z_0+Z_g(j\omega)\}\cdot i(\tau)\cdot e^{j\omega(t-\tau)}d\tau d\omega$$

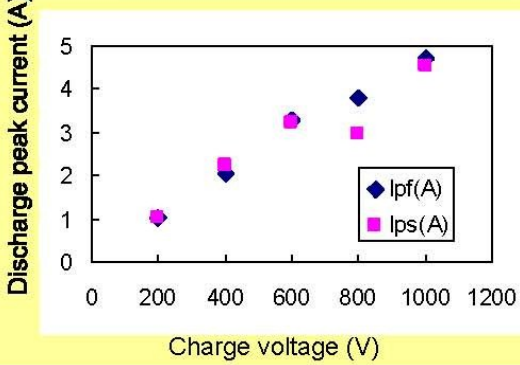
Influence of Charge Voltage on Discharge Parameters



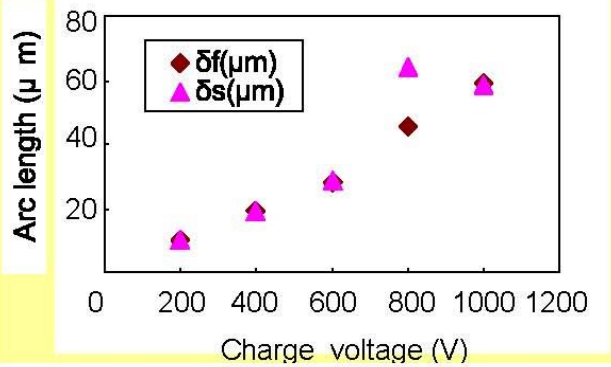
$$i(t)=\frac{1}{2\pi}\int_{-\infty}^{\infty}\int_{-\infty}^{\infty}\frac{V_c-v_g(\tau)}{Z_0+Z_B(j\omega)}\cdot e^{j\omega(t-\tau)}d\tau d\omega.$$

Determination of Channel Resistance and Arc Length

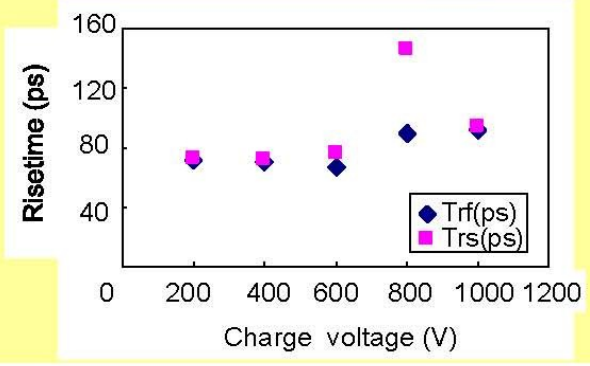
Electrode Moving Speed Influence on Current Peak Value at Various Voltage



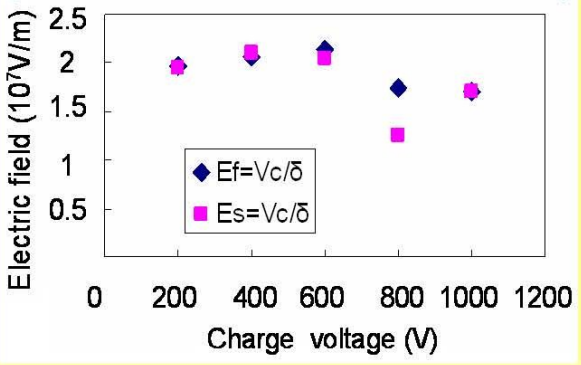
Electrode Moving Speed Influence on Arc Length at Various Voltage



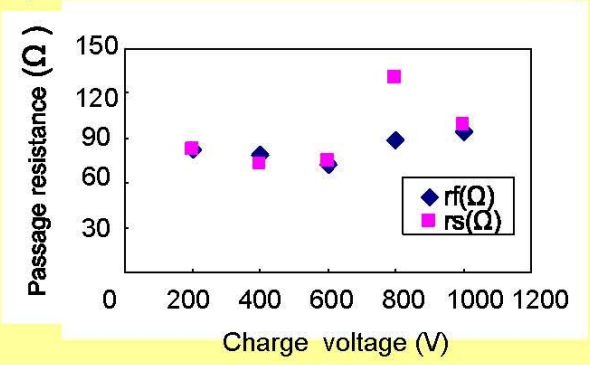
Electrode Moving Speed Influence on Arc Length at Various Voltage



Electrode Moving Speed and Charge Voltage Influence on Electric Field



Electrode Moving Speed and Charge Voltage Influence on Passage Resistance



Electrode Moving Speed and Charge Voltage Influence on Discharge Parameters

- Discharge parameters affected by electrode moving speed have little change at charge voltage 0.3kV.
- Electrode moving speed have distinctive effect on discharge current peak value when charge voltage is 0.8kV.
- Influence on discharge parameters by electrode moving speed, as Vc >1.5kV, larger than that caused by Vc=0.3kV, and less than that by Vc =0.8kV.

Correlation and Statistic Analysis between Discharge Parameters and Electrode Moving Speed

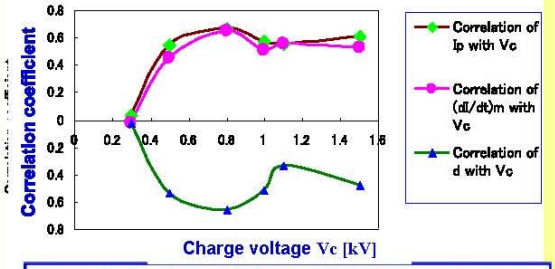
Table 1 Correlation coefficients with contact moving speed for different charge voltages

V_C [kV]	Correlation coefficients					
	Current peak		Max Rising slope		Spark length	
0.3	0.029	NS	-0.022	NS	-0.028	NS
0.5	0.544	**	0.452	**	-0.532	**
0.8	0.668	**	0.644	**	-0.656	**
1.0	0.572	**	0.511	**	-0.516	**
1.1	0.555	**	0.557	**	-0.338	*
1.5	0.612	**	0.522	**	-0.482	**

NS --- no significant correlation; * --- $p < 0.05$ ** --- $p < 0.01$

SPSS: Statistical Package for Social Science

Effect Analysis of Discharge Parameter Threshold Phenomenon with Charge Voltage



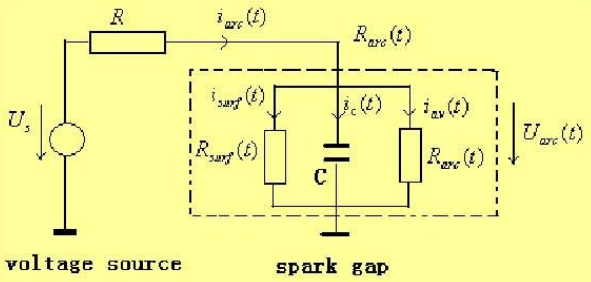
Correlation Coefficient with Charge Voltage

Threshold Phenomenon of Electrode Moving Speed Effect Change with Charge Voltage

表 5-1 小间隙放电的三类参数设置范围

参数范围	1	2	3
放电间隙(μm)	<10	20-80	80-100
上升时间(ps)	<40	300-600	<350
击穿电压(V)	<700	700-2000	>1500
场强(kV/mm)	>50-100	25-75	<8-35
放电波形	无台阶	有台阶	无台阶
阴极影响	有	无	无
阳极影响	无	有	有
气压影响	无	有	有
所属过程	表面	表面和容期	容期

Threshold Phenomenon of Electrode Moving Speed Effect Change with Charge Voltage



Analysis of Short-gap ESD Model

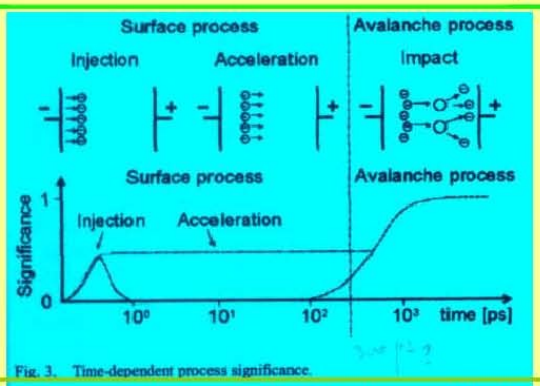
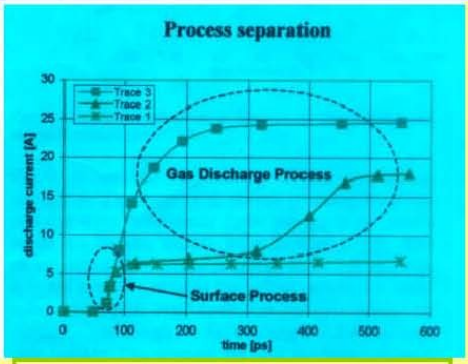


Fig. 3. Time-dependent process significance.

Short-gap Electrostatic Discharge Model

Threshold Phenomenon Analysis with Short-gap ESD Model

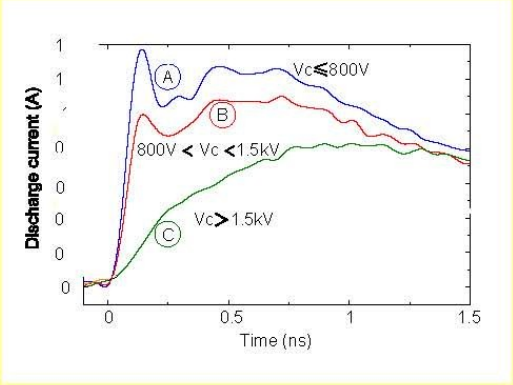


Short-gap Electrostatic Discharge Model

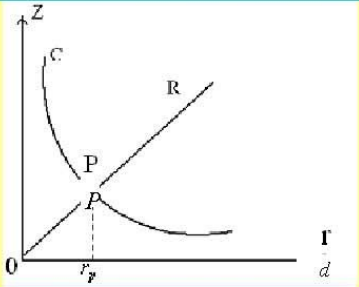
Threshold Phenomenon of Electrode Moving Speed Effect Change with Charge Voltage

The cause is that surface process transfers to avalanche process, shown key point at Vc=800V. Both surface process and avalanche acted at Vc=800V. For Vc < 800V, ESD event mainly determined by surface process ; as Vc >800V influence of surface process decrease and ESD event dominated by avalanche process. Special threshold phenomenon of electrode moving effect, hence, produced by comprehensive action of surface process and avalanche process.

Sorts of Discharge Current to Various Charge Voltage



Threshold Phenomenon of Electrode Moving Speed Effect Change with Charge Voltage

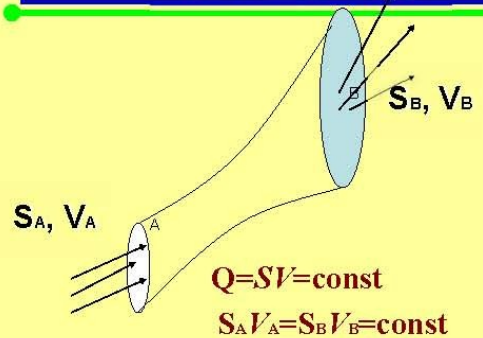


Relationship of channel resistance R, distributive capacitance and discharge gap

Mechanism Analysis of Electrode Moving Speed Effect Based on Fluid Mechanics Principles

Air flow motion, as a kind of fluid, follows the basic theorems, principles and laws in fluid mechanics. Analysis was given based on principle of continuity and Bernoulli theorem and discussion of gas press difference between inner and outer gap，obtained a new theoretical description on mechanism of electrode moving speed on discharge parameters.

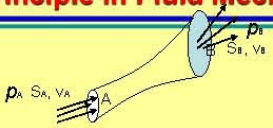
Continuity Equation---A Basic Principle in Fluid Mechanics



$$Q=SV=\text{const}$$

$$S_A V_A = S_B V_B = \text{const}$$

Bernoulli Equation--- Another Basic Principle in Fluid Mechanics

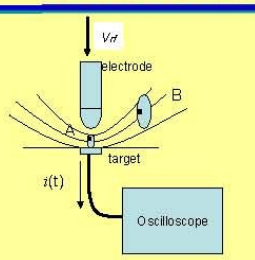


$$p_B - p_A = \frac{1}{2}\rho(v_A^2 - v_B^2) + \rho g(h_A - h_B)$$

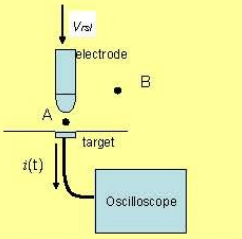
$$p_B + \rho g h_B + \frac{1}{2}\rho v_B^2 = p_A + \rho g h_A + \frac{1}{2}\rho v_A^2$$

$$p + \rho g y + \frac{1}{2}\rho v^2 = const.$$

Mechanism Analysis of Electrode Moving Speed Effect on Discharge Parameters



(a) Fluid tube formed when $P_A < P_B$



(b) No fluid tube formed for, $P_A = P_B$

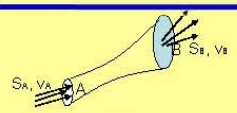
Mechanism Analysis of Electrode Moving Speed Effect on Discharge Parameters

$$p_A = p_B - \frac{1}{2}\rho\left[\left(\frac{S_B}{S_A}\right)^2 - 1\right]v_B^2$$

$$\left[\left(\frac{S_B}{S_A}\right)^2 - 1\right] > 0$$

$$p_A < p_B$$

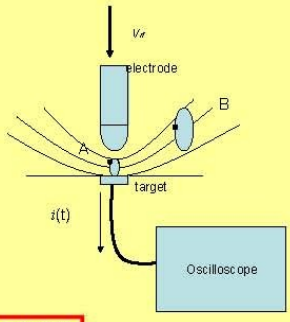
Mechanism Analysis of Electrode Moving Speed Effect on Discharge Parameters



$S_A V_A = S_B V_B = \text{const}$

$$i = i_0 e^{\alpha d}$$

$$\frac{\alpha}{P} = A\exp\left(\frac{-B}{E/P}\right)$$



Townsend Theory of Gas Discharge

Numerous Algorithm Analysis of Electrode Moving Speed Effect on Discharge Parameters

Electron moving speed v_e has strong correlation with gas pressure *p* *in short-gap ESD*

$$i(t)_{av} = C\frac{dV}{dt} + eN_0\frac{v_e}{d}\exp\left(\int_0^t \alpha(\xi)v_e(\xi)d\xi\right) \quad (3.2.15)$$

$$i(t)_{surf} = \frac{4}{9}\varepsilon_0\sqrt{\frac{2e}{m_e}}\cdot\frac{S_n(t)\cdot V(t)^{\frac{3}{2}}}{\left(d - v_e(t)\cdot t\right)^2}K[\alpha(t)] \quad (3.2.19)$$

$$\alpha = Ap\exp\left(-\frac{Bp}{E}\right)$$

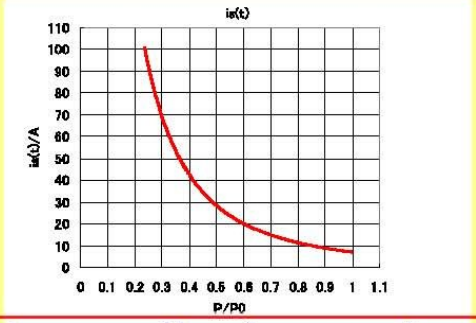
Numerous Algorithm Analysis of Electrode Moving Speed Effect on Discharge Parameters

$$v_e(t) = C\cdot\left(\frac{E}{p}\right)^{\frac{1}{2}}$$

$$C = 3.3\times10^6\,\frac{cm^{3/2}torr^{1/2}}{sV^{1/2}}$$

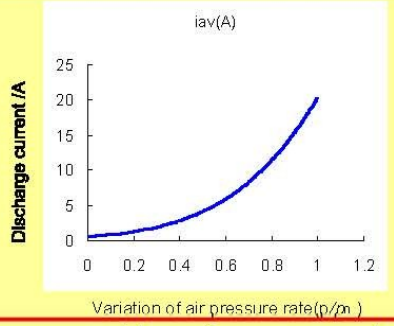
Discharge current variation situation, based on formulas above and parameters relative, can be estimated according to gas pressure variation, seeing in two figures blow

Numerous Algorithm Analysis of Electrode Moving Speed Effect on Discharge Parameters



Discharge current in surface process increase much with gas pressure decreased

Numerous Algorithm Analysis of Electrode Moving Speed Effect on Discharge Parameters



Discharge current in surface process decrease rapidly with gas pressure increase

Numerous Algorithm Analysis of Electrode Moving Speed Effect on Discharge Parameters

With consideration gas pressure changed by electrode moving speed, and electrical field strength varied by capacitance between two poles, the formula below is used to describe capacitance between two poles

$$C = \frac{S}{4\pi kd} \quad (4.3.14)$$

And hence deduct , combined (4.3.11), (4.3.12) ,discharge current formula as following

$$i(t) = \frac{dQ(t)}{dt} = i_0\exp\left[\left(d_0 - V_h t\right)AP\exp\left(\frac{-BpS}{4\pi kQ(t)}\right)\right] \quad (4.3.15)$$

Numerous Analysis of Electrode Moving Speed Effect

$$i(t) = \frac{dQ}{dt} = i_0\exp\left[\begin{array}{l}(d_0 - V_h t)A\left(p_B - \frac{1}{2}\rho\left(1-\left(\frac{1}{100}\right)^2\right)V_h^2\right)\bullet \\ \bullet\exp\left(\frac{-\left(p_B - \frac{1}{2}\rho\left(1-\left(\frac{1}{100}\right)^2\right)V_h^2\right)BS}{4\pi kQ(t)}\right)\end{array}\right]$$

Numerous Analysis of Electrode Moving Speed Effect

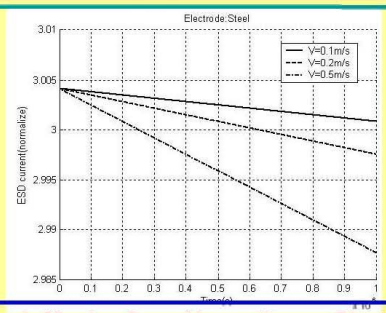
$$\frac{dQ}{dt} = \exp\left[\begin{array}{l}(10^{-4} - V_h t)A\left(10^5 - 0.65^2 V_h^2\right)\cdot \\ \cdot\exp\left(\dfrac{-\left(10^5 - 0.65^2 V_h^2\right)B \times 0.035 \times 10^{-13}}{Q(t)}\right)\end{array}\right]$$

$d_0 = 10^{-4} m$ $V_h = 0.1m/s, 0.2m/s, 0.5m/s$ $p_B = 10^5$ Pa,

$\rho = 1.293 \mathrm{kg/m^3}$ $S = 4 \times 10^{-6} m^2$ $\varepsilon = \frac{1}{36\pi} \times 10^{-9} F/m$

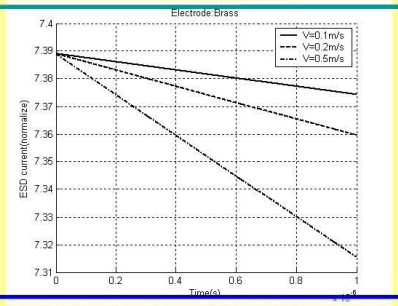
$k = 8.9 \times 10^9$ $\mathrm{Nm^2/C^2}$

Numerous Analysis of Electrode Moving Speed Effect



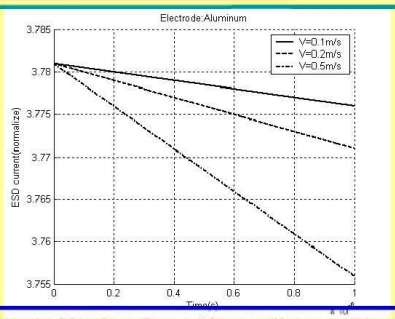
Electrode Moving Speed Impacting on Discharge Current (Stainless steel electrode)

Numerious Analysis of Electrode Moving Speed Effect



Electrode Moving Speed Impacting on Discharge Current(Cu electrode)

Numerous Analysis of Electrode Moving Speed Effect



Electrode Moving Speed Impacting on Discharge Current(Al electrode)

Experiment Verification of Electrode Moving Speed Effect

Creativity: (1) Realization of electrode straight line at large speed to the target without damage ; (2) Full sealed chamber enabling accurate control of different factor measurement (Protected by China Patent!)

Experiment Verification of Electrode Moving Speed Effect

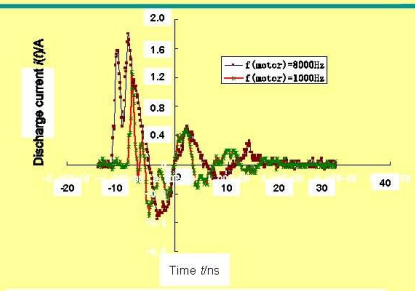


Fig5 Comparison of two electrode speeds in ESD events

Experiment Verification of Electrode Moving Speed Effect

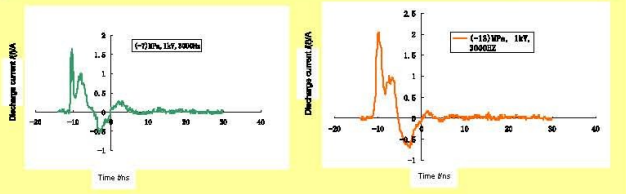
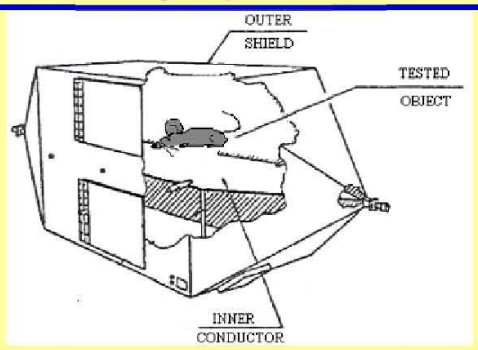


Fig7 Discharge current with comparatively high gas pressure in ESD

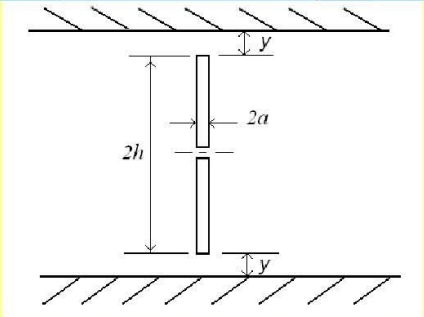
Fig8 Discharge current with comparatively low gas pressure in ESD

Algorithm Calculating Human Body Impedance



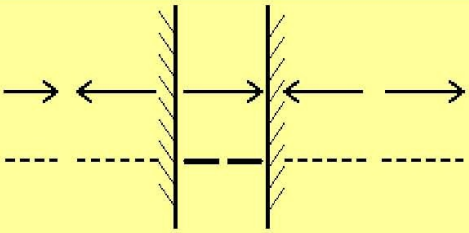
System Structure of Electromagnetic Wave Radiation

Algorithm Calculating Human Body Impedance



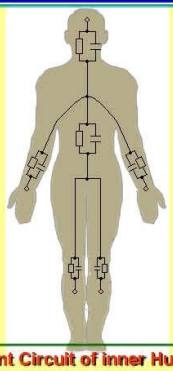
Configuration of Correct Antenna

Algorithm Calculating Human Body Impedance



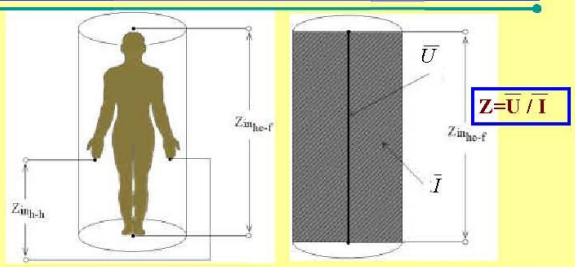
Mirror Reflection of Electromagnetic Wave

Algorithm Calculating Human Body Impedance



Equivalent Circuit of inner Human Body

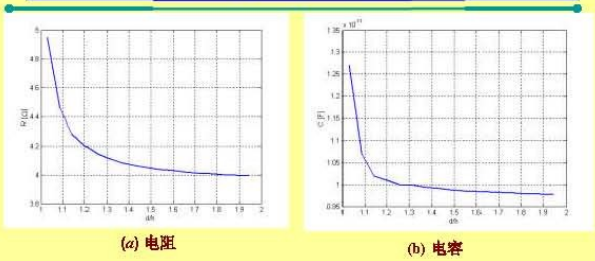
Algorithm Calculating Human Body Impedance



Option of input terminals Calculation method of impedance

Calculating Impedance with Cylindrical Model of Human Body

Algorithm Calculating Human Body Impedance



(a) 电阻　　(b) 电容

Calculation Result for Cylindrical Model Set in TEM Chamber

Conclusion

Short –gap exist popularly in aerospace and astronautic field, military weapons, and industry products important theory significance and practical application value rely on research of non-contact ESD properties. Deep investigation will provide benefit theoretical and technical reference to proposal of test standards of non-contact electrostatic discharge.

Tank You Very Much for Your Attention!

莱茵霍尔·盖特纳

莱茵霍尔·盖特纳于 1987 年毕业于慕尼黑技术大学，获得物理学学位。毕业后就职于慕尼黑联邦国防军大学，主攻防静电包装材料检测技术。后以防静电独立顾问角色，从事防静电工作。随后于 1996 年加入西门子半导体集团，即英飞凌(Infineon)，在英飞凌国际，其负责处理外部防静电问题；同时也负责处理防静电产品业务和防静电设备合格性测试业务。盖特纳先生于 1989 年开始进行静电放电控制讲授，两年后成为德国防静电协会活跃会员，并与几年后成为协会副主席。1995 年，就职于 IEC TC101 ESD 标准化协会，负责统筹召集静电衰变小组和设备测试小组联合会议。盖特纳先生于 2009 年获得 ESDA 杰出贡献奖，并与 2011 年成为 ESDA 理事会委员，负责组织国际工厂研讨会。盖特纳先生同时也是工业理事会委员，积极参与以实现静电放电控制目标。

Reinhold Gaertner

Reinhold Gaertner received his diploma in physics from the Technical University of Munich in 1987. Then he joined the Federal Armed Forces University Munich, where he was working on measurement techniques for ESD protective packaging materials. After working as an independent ESD consultant he joined Siemens Semiconductors in 1996 which is now Infineon Technologies. He is responsible for all problems regarding external ESD protection at Infineon worldwide and also for problems in customer production as well as for ESD device testing for qualification. Since 1989 he is lecturing on static control and since 1991 he is an active member of the German ESD association, where he is acting as Vice president since a couple of years. Since 1995 he is working in the ESD standardisation of IEC TC101 where he is convenor of two working groups at the moment (static decay and device testing). In 2009 he received the Outstanding Contribution Award of the ESDA and in 2011 he joined the BoD of the ESDA where he is responsible for international factory symposia. He also an active member of the Industry Council on ESD target values.

自动化生产线中的设备受到CDM作用的情况分析

Reinhold Gaertner

infineon

目标

通过下列方式比较验证期间和现场的ICs(CDM类似的)的ESD风险：

- 电压等级
- 放电电流波形

根据放电波形，对已安装在PCB上的IC的CDM风险提供分析。

2

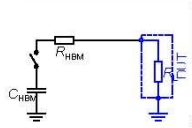
概述

- 动机
- 生产中可能存在的风险情况
- 实验细节
  - 测量技术和试样
- 实验结果
  - 放电头的对比
  - 与CDM对应的带电板情况
  - 放电情况
- 总结与结论

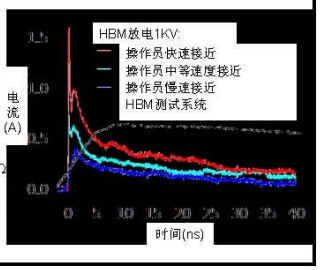
3

人体放电模型(HBM)

重现人体对IC的放电，该IC的各个不同电势至少装有一个引脚（在ESD防护区中处置！）

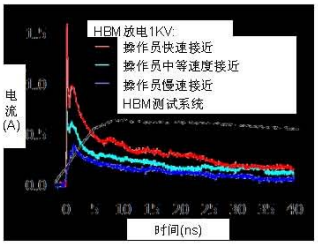


C_{HBM} = 100 pF, R_{HBM} = 1.5 kΩ
I_{HBM}/V_{HBM} = 0.67 A/kV
$t_{脉冲}$ = 150 ns, $t_{上升}$ = 2–10 ns



HBM – 放电波形

- 操作员向Pellegrini目标放电：



HBM – 现实世界中的威胁

- 因人员接地不足而引起的系统性故障在现实世界中几乎不存在，原因如下:
  - 多年来人员接地条件不断改善（防静电材料质量提升，防静电腕带、地防静电地板、防静电鞋等）
  - 大量备选措施; 通常不只一种ESD防护措施
  - 一般来讲人工手动处理程序减少
- 测试系统中与现实世界中的CDM作用的相关性较低; CDM作用量级在验证过程中比在现场更严重。

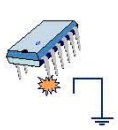
HBM –相关性测试/现场

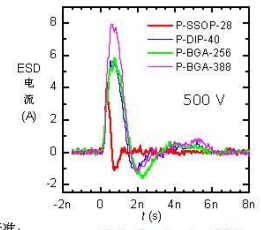
- 经验:
  - 不充分的ESD防护措施（罕见！）引起的现场问题可以通过HBM测试再现
  - HBM测试仪中的CDM作用比现实中的更严格
  - 如果人体带电电压在100 V以下，那么操作V_{HBM}大于 100 V的设备无任何HBM风险。

→HBM鲁棒性水平对于生产线和装配线是绝对有用的。

带电器件模型(CDM)

CDM再现IC向导体表面放电（在EPA中处置）



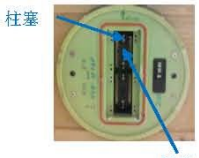


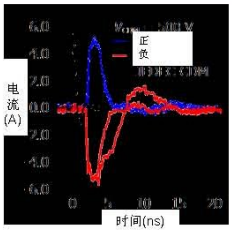
波形确认:
I_P/V_{CDM} = 5–15 A/kV
t_{FWHM} (FWHM) = 1–2 ns,
$t_{上升}$ = 250–500 ps
注: JEDEC 和 ESDA整合为联合标准: JEDEC/ANSI/ESD JS-002。

(参考: Brodbeck, 1998)

CDM – 放电波形

处理器的测试端:





- 结果:
  - 峰值电流相似（相同的放电头！）
  - 处理器的FWHM较大（C较高，Q较高）

CDM –相关性测试/现场(1)

- CDM测试仪中的电压水平和现场的电压水平不可能直接相关:
  - 测试仪中定义的电压水平下的电流波形取决于测试设置（ESDA / JEDEC / JEITA）
  - 现场中元件电容（→放电）和/或元件放电区域的电容是不可比较的，与放电路径中的电感（→波形）也是不可比较的。
- CDM测试仪场景（放电到一个巨大的金属盘上）在现实中很少见。

CDM –相关性测试/现场(2)

- 通常在现场中观察到"CDM-型"放电，其波形与CDM测试器波形不同，这是由不同的电容和电感造成的（例如带电板模型）
- 经验:
  - CDM测试解决了HBM未涵盖但却相当常见的故障模式
  - 如果元件带电为V <100 V，那么元件带电V_{CDM}> 100 V是可以安全处理的.

→ CDM鲁棒性水平对于装配线非常重要；联合标准是有益的!

器件水平总结

- 由于ESD防护措施不断改进，HBM的威胁降低了
- 更多的自动处理步骤和CDM敏感性的增加，CDM的威胁增加了
- 电压可以很容易地测量，但验证试验和现场之间没有（简单的）相关性
- 重要提示：测量和比较验证期间与现场的放电电流！
- 讨论：安装在PCB上的器件由于CDM类似放电而更加危险

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器件生产中可能存在的风险

- 在验证测试期间，器件带电并放电到相当大的金属接地层
  =>现场是否存在类似的情况?
- 器件制造期间的CDM类似事件
  – 引线键合
  ⇒ 没有大金属板
  ⇒ 难以测量
  ⇒ 可以通过没有接地板的放电头模拟
  – ATE 处理

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在PCB生产中可能的风险

- PCB制造期间的CDM类似事件
  – 处置（仅单个器件CDM类事件）
  ⇒ 没有大的金属板，只有PCB的电容
  – 带电板事件
    - 内电路测试
    - 一般测试
    - 焊接
    - …

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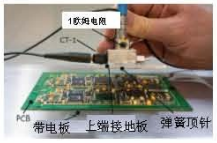
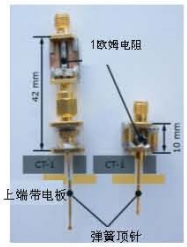
测量技术

- PCB上用于测量的特殊放电头
  – 可更换的弹簧引脚
  – 1欧姆接地(20 GHz)
  – CT-1 (1 GHz)
- 示波器 (8 – 15 GHz)





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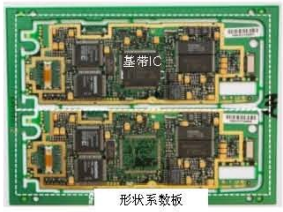
试样

- 已经在如下条件下完成测量：
  – CDM验证模块
  – 不同的器件
  – 不同的PCB



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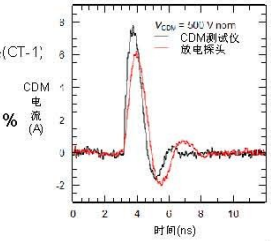
结果

- 放电头对比
  – 通过利用如下装置在基带IC上完成比较测量：
    - 商用的CDM测试仪
    - 带电流探头的自制放电头(CT-1)

=> CT-1 的数据降低15 – 20 %



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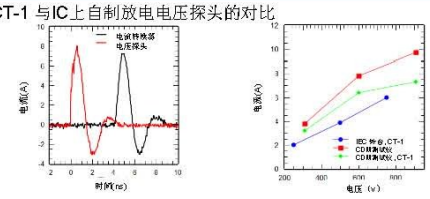
放电头对比

- CT-1 与IC上自制放电电压探头的对比



- CT-1的数据仅降低10%
- 塑料箔覆盖的金属台上的峰值电流小于CDM测试仪

=> CDM测试仪的情况最遭!

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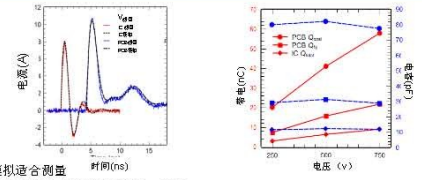
CBE 与 CDM对比



- 模拟适合测量
- PCB的峰值电流比IC高20% - 30%
  - 如果峰值电流是主要根本原因，则故障临界值大致相同
  - 初始峰值后的波形起着重要作用
    - 主要取决于PCB和放电位置
    - 持续时间为10ns-50ns，CDM峰值的10%-50%导致典型的具有高能量的能量状态

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放电情形

- 在CDM测试系统中，被测设备出现了较好的放电情形
  - 接地的固定（非常小）的距离导致大的电容
  - 固定的放电盘（大于DUT）在固定（小）的距离起着大的虚拟接地作用
  - 固定（短）的放电引脚长度导致了固定（小）的电感
- 实际上，所有参数通常不同（更小的电容，更小的虚拟接地，更大的电感）

=> CDM测试仪代现了最糟情形！

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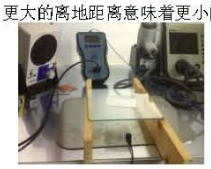
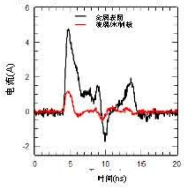
接地距离的影响

- 放置在金属板上的PCB与大地相距距离（0.5mm）较近，这是最糟糕的情况
- 实际上，PCB和大地之间的距离要远得多
- 更大的离地距离意味着更小的电容和更小的放电电流





置于金属表面的或距离相同的双脚口智能卡的放电- 同样适用于仅在侧面支撑运行的的输送带上的PCB

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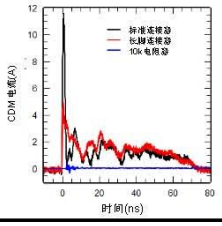
放电引脚的影响

- CDM测试仪中放电引脚短，这种情况最糟
- 现实中，放电引脚/元件较长，电感较大，有时甚至会带些电阻
- 较长的放电元件或者电阻元件导致放电电流较小



带电方法的影响

- CDM测试仪中近距离平行于板（电场垂直于PCB）的带电板是最坏情况的情形
- 实际上，电场与板平行（例如，邻近传送带的带电机器盖），导致带电（较低的感应电压）量较低，因此放电电流较少
- 情景模拟：一个带电的金属板（模拟带电机器部件）前放置一个木制支撑（模拟耗散输送带），同时，板放于木质支撑上
- 使用接触电压计测量感应电压

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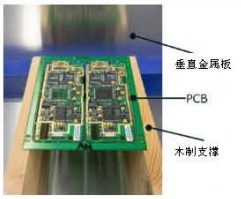
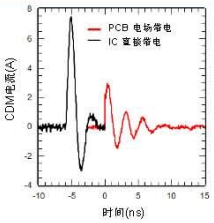
带电方法的影响 – 续





- 金属板（离PCB的距离为2cm）带电至500V导致PCB上带电150V（PCB上带电500V需要金属板带电3kV）
- 并联电场中带电的PCB的放电电流要小得多

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总结和结论

- 在PCB生产的过程步骤中几乎不可能发生“单器件CDM事件”
- 发生带电板事件的可能性更多
- 单个器件上和带有“手动”放电头PCBS上进行的放电电流测量依据CDM器件测试标准
- 结果表明，在相同的放电情况下，峰值电流不会明显增加，但通过器件传输的电荷总量更高=>器件的CDM作用更高
- 此外，在现场的CDM类似事件比在CDM测试仪中的更舒缓=>CDM测试情况最糟。

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What CDM stress does a device see in an automated production line?

Reinhold Gaertner

infineon

Objectives

To compare the CDM-like ESD-stress of ICs during qualification and in the field by means of

- Voltage levels
- Discharge current waveforms

To provide an analysis of the CDM-risk of ICs already mounted on a PCB in terms of discharge waveforms

Slide 2

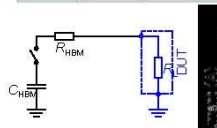
Outline

- Motivation
- Possible Risk Scenarios in Production
- Experimental Details
  - Measurements Techniques and Samples
- Results
  - Comparison of Discharge Heads
  - Charged Board Event versus Charged Device Model
  - Discharge Scenarios
- Summary and Conclusions

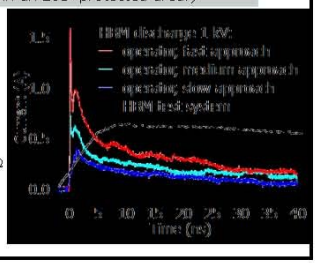
Slide 3

Human Body Model (HBM)

Reproduces a discharge of a human being into an IC which has at least one pin on a different potential (handling issue in an ESD-protected area!)

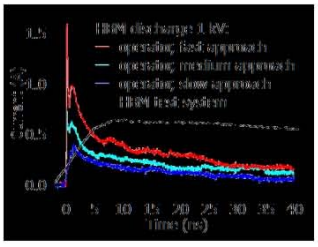


C_{HBM} = 100 pF, R_{HBM} = 1.5 kΩ
I_{HBM}/V_{HBM} = 0.67 A/kV
t_{pulse} = 150 ns, t_{rise} = 2–10 ns



HBM – Discharge Waveforms

- Discharge of operator into Pellegrini Target:



HBM – Threats in Real World

- Systematic failures which can be attributed unambiguously to inadequate personnel grounding are almost non existent in real-world; reasons:
  - Improved personnel grounding over years (improved material quality w.r.t. ESD properties of floor, shoes, wrist straps, ...)
  - Lot of back-up measures implemented; often there is more than only one ESD protection measure
  - General: less manual process steps
- Low correlation between stress in test system and in real world; stress during qualification order of magnitudes more severe than in field

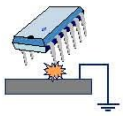
HBM – Correlation Testing/Field

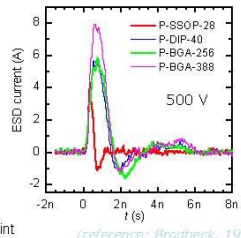
- Experiences:
  - Field problems caused by inadequate ESD protection measures (rare!) could be reproduced by HBM tests
  - Stress in HBM tester more stringent than in reality
  - If the charging of the personnel is limited to $V < 100$ V, devices with $V_{HBM} > 100$ V can be handled without any HBM risk

→HBM robustness level is absolutely useful for production and assembly lines

Charged Device Model (CDM)

CDM reproduces a discharge of an IC into a conductive surface (handling issue in an EPA)



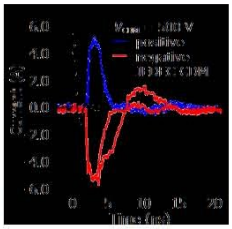


Waveform Verficication:
I_{PF}/V_{CDM} = 5–15 A/kV
t_{pulse} (FWHM) = 1–2 ns,
t_{rise} = 250–500 ps
Note: JEDEC and ESDA is now a Joint Standard JEDEC/ANSI/ESD JS-002

(reference: Brodbeck, 1998)

CDM – Discharge Waveforms

test side of handler:



- Results:
  - Peak currents similar (same discharge head!)
  - FWHM of handler larger (higher C, higher Q)

CDM – Correlation Testing/Field (1)

- Direct correlations of voltage levels in the CDM tester and in the field are almost impossible:
  - The current waveform at a defined voltage level in the tester depends on the test set-up (ESDA/JEDEC/JEITA)
  - Capacitance of the component to environment (→ charge) and/or capacitance of area in which the component discharges are not comparable, inductances in discharge path (→ waveform) are also not comparable
- CDM tester scenario (discharge into a huge metal plate) is only very rarely seen in reality

CDM – Correlation Testing/Field (2)

- Often "CDM-type" discharges are observed in the field with waveforms which differ from the CDM tester waveform due to different capacitances and inductances (e. g., Charged Board Model)
- Experiences:
  - CDM testing addresses a quite common failure mode which is not covered by HBM
  - If the charging of the components is $V < 100$ V, components with $V_{CDM} > 100$ V can be handled safely

→CDM robustness level is absolutely important for assembly lines; joint standard is beneficial!

Device Level Summary

- HBM threat reduced due to improved ESD protection
- CDM threat increased due more automated handling steps and increased CDM sensitivity of modern devices
- Voltages can easily be measured, but no (simple) correlation between qualification test and field
- Important: to measure and compare the discharge current in the field with the one during qualification!
- Ongoing discussion that devices mounted on a PCB are even more endangered by CDM-like discharges

Slide 12

Possible Risks in Device Production

- During qualification test the device is charged up and discharges into a rather big metal ground plane
  => do we have such a scenario in the field?
- CDM-like events during device manufacturing
  - Wire bonding
    - ⇒ no big metal plane
    - ⇒ Difficult to measure
    - ⇒ Can be simulated by discharge head without a ground plane
  - ATE handling

Slide 13

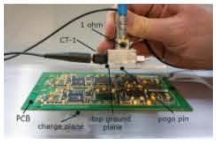
Possible Risks in PCB Production

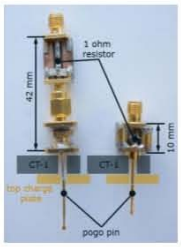
- CDM-like events during PCB manufacturing
  - Placement (only single device CDM-like event)
    - ⇒ no big metal plane but capacitance of PCB
  - Charged Board Events
    - In-Circuit Test
    - Testing in general
    - Soldering
    - …

Slide 14

Measurement Techniques

- Special discharge head for measurements on PCBs
  - exchangeable pogo pin
  - 1 ohm to ground (20 GHz)
  - CT-1 (1 GHz)
- Oscilloscope (8 – 15 GHz)





Slide 15

Samples

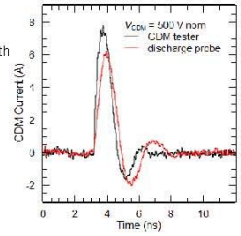
- Measurements have been done on
  - CDM verification modules
  - Different devices
  - Different PCBs

Slide 16

Results

- Comparison of discharge heads
  - Comparative measurements done on baseband IC with
    - Commercial CDM tester
    - Self-made discharge head with a current probe (CT-1)

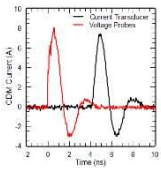
=> CT-1 is 15 – 20 % smaller

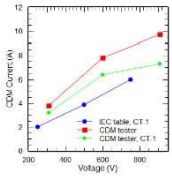


Slide 17

Comparison of discharge head

- CT-1 vs. voltage probe in self-made discharge head on IC



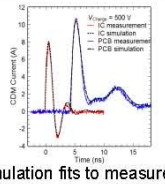


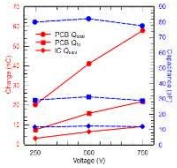
- CT-1 is only 10% smaller
- Peak current on metal table covered with plastic foil smaller then in CDM tester

=> CDM tester is worst case!

Slide 18

CBE vs CDM





- Simulation fits to measurement
- Peak current of PCB 20% - 30% higher than for IC
  - Roughly same failure threshold if peak current is main root cause
  - Waveform after initial peak plays significant role
    - mainly depending on PCB and discharge location
    - Duration of 10ns – 50 ns and 10% - 50% of CDM peak results in typ. energetic regime with high energies

Slide 19

Discharge Scenarios

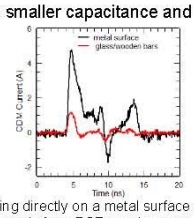
- In the CDM test system the DUT sees a well defined discharge scenario
  - Fixed (very small) distance to ground resulting in a big capacitance
  - Fixed discharge plate (bigger than DUT) at fixed (small) distance acting as a big virtual ground
  - Fixed (short) length of discharge pin resulting in a fixed (small) inductance
- In reality all these parameters are normally different (smaller capacitance, smaller virtual ground, bigger inductance)

=> CDM tester represents worst case conditions!

Slide 20

Influence of distance to ground

- PCB laying on a metal plate isolated from ground with thin isolation (0.5 mm) is worst case scenario
- In reality distance between PCB and ground is much bigger
- Bigger distance to ground means smaller capacitance and lower discharge currents

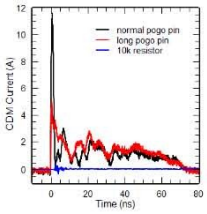


Discharge of dual interface smart card laying directly on a metal surface or same distance away – the same would apply for a PCB running on a conveyor belt supported only at the side

Slide 21

Influence of discharge pin

- Short discharge pin as in CDM tester is worst case scenario
- In reality discharge pins/elements are longer with bigger inductance and sometimes even some resistance
- Longer discharge elements or even resistive elements are resulting in smaller discharge currents



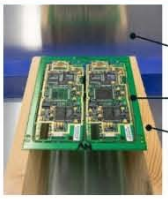
Slide 22

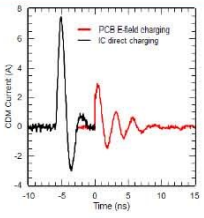
Influence of charging method

- Charged plane in close distance to parallel to board (field perpendicular to PCB) as in CDM tester is worst case scenario
- In reality the electric field is in parallel to the board (e.g. charged machine cover next to a conveyor belt) resulting in a lower charging (lower induced voltage) and therefore lower discharge currents
- Scenario was simulated with a board on wooden support bars (simulating the dissipative conveyor belt) in front of a charged metal plate (simulating charged machine parts)
- Induced voltage was measured using a contact voltmeter

Slide 23

Influence of charging method – cont.





- Metal plate (2 cm away from PCB) charged to 500 V results in a charging of the PCB of 150 V (3 kV on metal plate needed for 500 V on PCB)
- Discharge current from PCB charged by parallel E-field is much smaller

Slide 24

Summary and Conclusion

- Nearly no process step in PCB production where a “single device CDM event” can happen
- Much more possibilities for a Charged Board event
- Discharge current measurements where taken on single devices and PCBS with “manual” discharge head built in accordance with CDM device testing standards
- Results showed that peak current is not significantly higher @ same discharge scenario, but total amount of charge transferred through device is higher => Higher stress for devices
- Results showed also that CDM-like events in the field are more relaxed than in the CDM tester => CDM tester is worst case

Slide 25

李义鹏

李义鹏，1980 年生，男，汉族，山东青岛人。硕士，高级工程师。2007 年进入中国石化青岛安全工程研究院，有十余年从事石化企业油品静电安全、粉体静电安全等相关工作经验，承担中国石化集团公司级科研项目六项，参与国家科技支撑项目一项，发表论文十余篇，获得发明专利授权两件。

Li Yipeng

Yipeng Li, born in 1980, male, master, senior engineer. Working in SINOPEC Research Institute of Safety Engineering from 2007, mainly engaged in electrostatic safety work from then on. He has undertaken 6 technical and research projects on the level of SINOPEC and participated in 1 national science and technology supporting project. More than 10 papers have been published in various magazines. Two patents for inventions have been accessed.

内 容 简 介

第一篇 粉体静电风险及防护

第二篇 油品静电风险及防护

第一篇 粉体静电风险及防护

万能型聚烯烃材料

聚烯烃是烯烃的聚合物，主要包括聚乙烯、聚丙烯等；

特点：
- 密度小
- 物、化性能稳定
- 加工性能好
- 环保、节约能源
- 价格低廉

1. 风送聚烯烃粉体带电
   - 粉体之间摩擦
   - 粉体与管道之间的摩擦与碰撞
   - 粉体颗粒碎裂
2. 聚烯烃生产、储运过程中的残留的乙烯、丙烯、氢气等可燃气体（体积分数0.1%-0.5%）与聚乙烯、聚丙烯粉尘形成耦合体系（杂混粉尘），耦合体系的MIE_H低。

杂混粉尘的最小点火能MIE_H

$$MIE_H = MIE_d \left(\frac{MIE_G}{MIE_d} \right)^{C/C_P}$$

MIE_G：气体最小电火能
MIE_d：粉尘最低电火能
C：可燃气浓度
Cp:气体引燃的敏感浓度

聚烯烃料仓防静电

➢ 聚烯烃料仓需要做好静电燃爆事故的预防工作。由于此类工艺的静电起电主要由粉体引起，而所处环境一般烯烃含量较大，极易发生静电燃爆事故。

视频 1
视频 2
视频 3

中石化10企业68次聚烯烃生产事故统计

	事故件数	百分比%
总件数	68	100
可燃气体与粉尘混合物粉尘类事故	61	90
与设计有关的	7	10
与设备维护有关的	48	70
与操作有关的	18	26
与处理不合格料有关的	10	15
其他	4	6

- 残留可燃气体与聚乙烯、聚丙烯粉尘形成耦合体系发生燃爆事故的风险更高。
- 从燃爆事故统计和分类上看，可燃气体的存在是导致爆炸的主要原因，约占全部事故的90%。

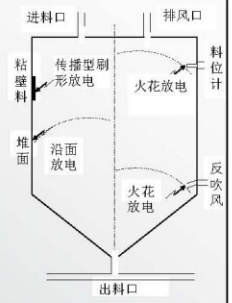
料仓内部可能存在静电放电形式

放电形式	电晕放电	刷形放电	沿面放电	火花放电	传播型刷形放电
放电能量	μJ级	1～4mJ	～10mJ	几十mJ以上	几百～上千mJ
放电部位	自放电	自放电	堆面积覆盖	金属突出物或立导体	>4mm静层或粘聚料
放电频率	连续	频繁	几十秒	少	很少
可引燃物料	无	可燃气	杂混合物	粉尘	粉尘
危险几率	无	较小	高	小	很小

聚烯烃生产生产必须：

1. 控制粉体带电量

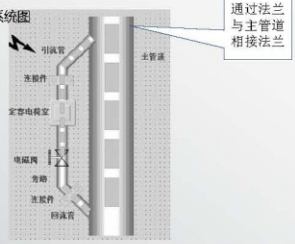
2. 控制可燃气体浓度



料仓粉体静电监测技术研究

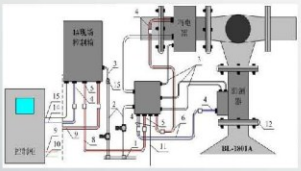
粉体静电监控系统基于定容式法拉第筒原理，通过旁路伸进主管道部分获取物料，并测试带电量。

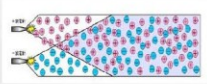
料仓静电监测系统图



料仓粉体静电消除技术研究

不平衡式双极性离子流静电消除技术，正、负放电针相间布置，简化控制目，提高离子流喷射距离；消电效率可达90%。





正、负放电针相间布置；同时施加正、负电压

料仓静电消除/监测系统简图

料仓粉体静电消除技术研究

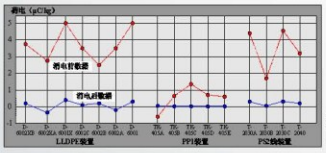
料仓静电消除/监测系统实物图

料仓粉体静电消除技术研究

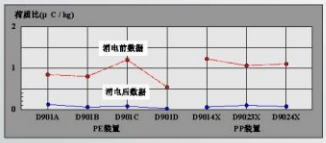
操作方便
安全可靠

料仓静电消除/监测软件控制系统

使用效果消电效率＞90%，剩余电荷量≤0.1μc/kg。

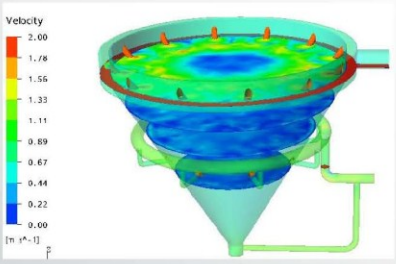


某企业LLDPE、PP、PS料仓消电器使用数据



某企业PE、PP料仓消电器使用数据

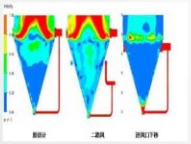
料仓反吹风脱气技术研究——控制可燃气体浓度



聚烯烃料仓粉体静电防护技术

料仓进口处安装静电消除器

料仓反吹风脱气技术



聚烯烃料仓静电燃爆防控技术

确定料仓安全料位，通过料仓反吹风脱气系统以及管道式离子风静电消除器，大大降低料仓静电燃爆风险，保障聚烯烃装置现场安全运行。

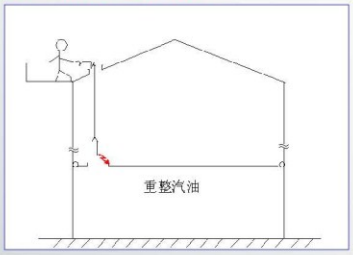
金属突出物防静电处理

第二篇 油品静电风险及防护

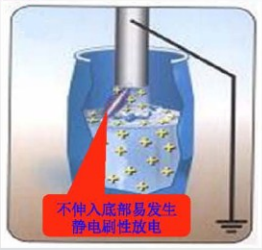
1. 石化企业静电危害部位

（1）油品汽车栈台
（2）火车栈台
（3）液化汽槽车栈台
（4）装置区内各种可燃液体装车点
（5）烯烃装车台
（6）油罐等容器清洗
（7）有限空间作业
（8）采样、检尺、测温、检水等作业
（9）油品过滤器
（10）汽车吸油与卸油
（11）船舶装油
（12）易喷油点，如装置区内的各种导淋阀管处等
（13）塑料桶装油
（14）油品罐装
（15）油品搅拌

油罐采样、检尺、测温作业



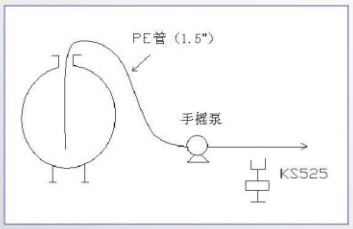
顶部喷溅式注油



过滤器材质（滤芯）起电过高

使用塑料桶装油

使用绝缘管装油



人体静电放电

2. 静电事故

静电事故主要原因(石油产品）

- 油品速度过快
- 油中含水作业
- 油罐采样、检尺、测温作业
- 顶部喷溅式注油
- 过滤器材质（滤芯）起电过高
- 使用塑料桶装油
- 油罐不接地
- 使用绝缘管装油
- 油罐内有孤立导体、金属突出物
- 人体静电放电等

内浮顶储罐静电事故

拱顶储罐静电事故

乙醇汽油装车事故

油罐车卸油

天津自助加油站事故

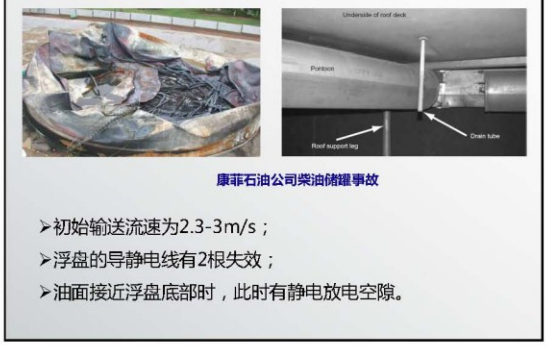
“8.29”中石油大连柴油储罐爆燃事故

2011年8月29日，大连石化公司储运车间一柴油罐收油过程中发生闪爆，罐底板撕裂，并起火燃烧，形成流淌火，引燃同一罐组其它罐保温层并引发罐内柴油少量轻组分闪爆。经扑救，历时3小时23分扑灭明火。

- 浮盘落床，浮盘以下液面与大气直接接触，为闪爆提供了氧气的条件。
- 入口管的瞬间流速最大值超过4.3m/s，形成喷溅式进油。
- 液面可能有金属漂浮物（如脱落的浮筒）的存在。

建议

- 严禁浮盘落床操作
- 罐区防火堤内的线缆应埋地敷设
- 封堵穿墙管线、及时关闭罐区排水系统
- 规范罐区工艺管线系统布置
- 严格执行设计规范，完善消防喷淋设施
- 严格控制、优化工艺操作条件
- 提高安全设计要求
- 加强检查油罐雷静电防护装置



康菲石油公司柴油储罐事故

- 初始输送流速为2.3-3m/s；
- 浮盘的导静电线有2根失效；
- 油面接近浮盘底部时，此时有静电放电空隙。

3. 油品静电消除方法

静电接地	储罐、管线等良好接地，接地电阻小于1MΩ。
工艺控制	多相混合时确保液体混合比例不变。 根据情况控制油品流速。
导电性好的管道	使用接地良好的金属管线。 使用具有导电功能的非金属管线。
使用抗静电添加剂	在电导率低的油品中加入抗静电剂。
静电缓和	油品有3倍的缓和时间。
静电消除	无源静电消除器。 有源静电消除器。

中国石化
SINOPEC

谢谢！

Brief Introduction of the Content

Part I Electrostatic Risk and Protection of Powder

Part II Electrostatic Risk and Protection of Oils

Part I Electrostatic Risk and Protection of Powder

Universal polyolefin materials

Polyolefin is a polymer of olefin, including polyethylene, polypropylene, etc.

Features:
- Low density
- Stable physical and chemical property
- Good processing characteristics
- Environment-friendly, energy saving
- Low price

1. Polyolefin powder blown by air with electricity
   - Friction of powder
   - Friction and collision between powder and pipeline
   - Particle fragmentation of powder
2. Flammable gas such as ethylene, propylene, hydrogen remained during the production and transportation of polyolefin (volume fraction 0.1%-0.5%) forms coupling system (mixed powder) with polyethylene and polypropylene powder, of which MIE_H is low.

Minimum ignition energy of mixed powder MIE_H

$$MIE_H = MIE_d \left(\frac{MIE_G}{MIE_d} \right)^{C/C_P}$$

MIE_G: Minimum ignition energy of gas
MIE_d: Minimum ignition energy of powder
C: Concentration of flammable gas
Cp: Sensitivity concentration of ignited gas

Anti-static of polyolefin stock bin

- Preventive measures for electrostatic blast accident need to be taken in polyolefin stock bin. Electrostatic discharge of this process is mainly caused by powder, and the ambient air contains a large amount of olefin, so blast accident caused by electrostatic discharge happens easily.

Video 1
Video 2
Video 3

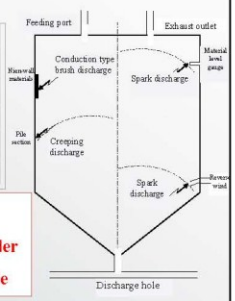
68 polyolefin production accidents of 10 subsidiaries of Sinopec

	Number of accidents	Percentage
Total	68	100
Powder accidents caused by mixture of flammable gas and powder	61	90
Accidents related to design	7	10
Accidents related to equipment maintenance	48	70
Accidents related to operation	18	26
Accidents related to handling of unqualified materials	10	15
Others	4	6

- The remaining flammable gas can form coupling system with polyethylene and polypropylene powder, which enhances the risk of blast accident.
- From the statistics and classification of blast accident, flammable gas is the main reason for explosion, accounting for approx. 90% of all accidents.

There may be electrostatic discharge in stock bin

Discharge mode	Corona discharge	Brush discharge	Creeping discharge	Spark discharge	Conduction type brush discharge
Discharge energy	Grade μJ	1~4mJ	~10mJ	More than several dozens of mJ	Several hundred to thousands of mJ
Discharge parts	Self-discharge	Self-discharge	Pile section to tank wall	Isolated conductor of model protrusions	Conductive coating or micro-wall materials
Discharge frequency	continuous	Frequent	Tens seconds	Few	Little
Ignitable material	None	Combustible gas	Miscellaneous mixtures	Dust	Dust
Risk rate	None	Smaller	High	Lower	Minimum



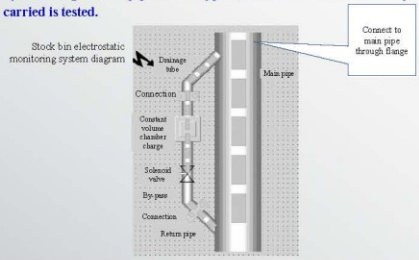
The production of polyolefin must:

1. Control electricity carried by powder

2. Control concentration of flammable gas

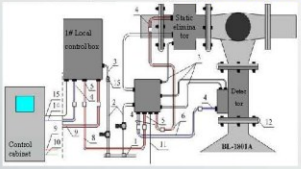
Research on powder electrostatic monitoring technology in stock bin

The powder electrostatic monitoring system is designed based on the principle of fixed - capacity Faraday cylinder. Materials are accessed by extruding to main pipeline via bypass, and the amount of electricity carried is tested.

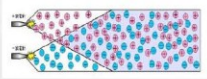


Research on powder electrostatic eliminating technology in stock bin

Unbalanced bipolar ion flow static mitigation technology, positive spray point alternating with negative spray point, simplify the number controlled in order to increase jet length of ion flow; The efficiency of static elimination reaches 90%.



Static elimination of stock bin /monitoring system diagram

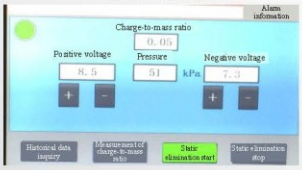


Positive spray point alternating with a negative spray paint, **positive and negative voltage imposed at the same time .**

Research on powder electrostatic eliminating technology in stock bin

Static elimination of stock bin /monitoring system

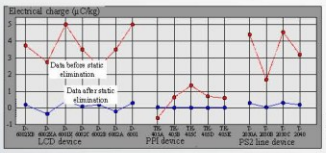
Research on powder electrostatic eliminating technology in stock bin



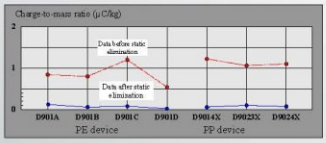
Easy operation
Safe and reliable

Static elimination of stock bin /monitoring software control system

Using effect Efficiency of static elimination > 90%, residual charge ≤0.1μc/kg

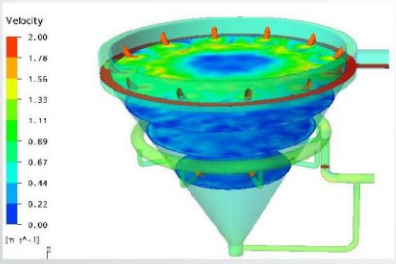


Using data of LLDPE, PP, PS stock bin static eliminator of an enterprise



Using data of PE, PP stock bin static eliminator of an enterprise

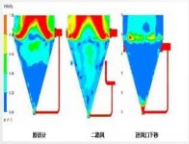
Research on stock bin reverse blowing degassing technology--control the concentration of flammable gas



Static protection technology of powder in polyolefin stock bin

Install static eliminator at stock bin inlet

Stock bin reverse blowing degassing technology



Technology of electrostatic blast control in polyolefin stock bin
With the safety position of stock bin located, the technology could significantly reduce the risk of electrostatic blast of stock bin by the reverse blowing degassing system and the pipeline type ion wind static eliminator, and ensure safe operation of polyolefin equipment.

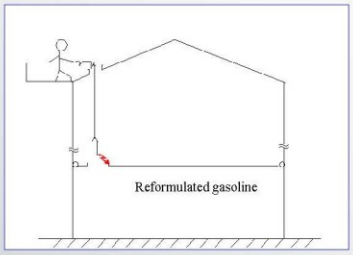
Anti-static treatment of medal protrusion

Part III Electrostatic Risk and Protection of Oils

1. Electrostatic hazard area of petrochemical enterprises

(1) Oil tank car platform
(2) Train platform
(3) Liquid gas tank car platform
(4) Flammable liquid and gas loading points in plan area
(5) Olefin loading platform
(6) Cleaning of containers such as oil tank
(7) Limited space work
(8) Sampling, scale measuring, temperature testing, water inspection, etc.
(9) Oil filter
(10) Oil loading and unloading of car
(11) Ship oil loading
(12) Oil injection point, such as guide valves and guide pipes in plant area
(13) Oil loading by plastic bucket
(14) Oil tank loading
(15) Oil stirring

Oil tank sampling, scale measuring, temperature testing

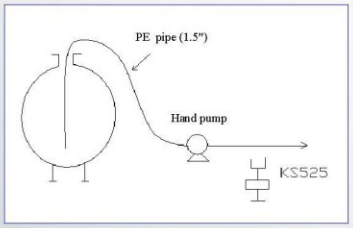


Spray-type oil injection from the top

The material of filter (filter element) has high electrification

Use plastic bucket as oil container

Use insulated pipe as oil container



Human-body electrostatic discharge

2. Electrostatic accidents

Main reasons of electrostatic accident (petroleum product)

- Too fast oils speed
- Work with oil containing water
- Oil tank sampling, scale measuring, temperature testing
- Spray-type oil injection from the top
- The material of filter (filter element) has high electrification
- Use plastic bucket as oil container
- No grounding to oil tank
- Use insulated pipe as oil container
- There are isolated conductor and medal protrusion in oil tank
- Human-body electrostatic discharge, etc.

Electrostatic accidents of inter floating roof tank

Electrostatic accidents of cone roof storage tank

Ethanol gasoline loading accidents

RTC unloading

Tianjin self-service gas station accident

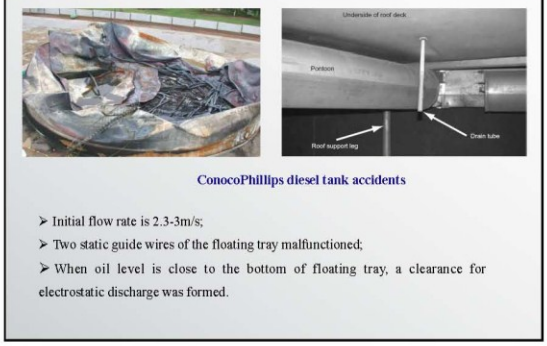
"8.29" PetroChina diesel tank explosion accident in Dalian

On August 29, 2011, a diesel tank in storage and transportation workshop of Dalian Petrochemical Company exploded during oil collection. Bottom plate of tank was torn apart and ignited, forming a flowing fire, which ignited other insulated layer of other tanks in the same unit and generates flash explosion of little light component in diesel. The open fire was put out after three hours and twenty-three minutes of fighting.

- The floating tray dropped, leading to direct contact of liquid level under the floating tray with air, and providing oxygen for flash explosion.
- The maximum instant flow speed at inlet tube exceeded 4.3m/s, forming spray-type oil-taking.
- There may be medal floating objects in the liquid level (e.g. dropped buoy).

Suggestions

- It is forbidden to operate when the floating tray drops
- Cable in fire bank of tank farm should be embedded underground
- Block off pipeline passing through walls, close water drainage system in tank farm timely
- Standardize the arrangement of process pipeline system in tank farm
- Implement design specification strictly, improve fire-fight spraying facilities
- Control and optimize process operating conditions strictly
- Enhance safety design requirements
- Strengthen the inspection of lightning and static protection device in oil tank



ConocoPhillips diesel tank accidents

- Initial flow rate is 2.3-3m/s;
- Two static guide wires of the floating tray malfunctioned;
- When oil level is close to the bottom of floating tray, a clearance for electrostatic discharge was formed.

3. Static elimination methods of oils

Electrostatic grounding	Tanks and pipelines are grounded well, and the grounding resistance should be less than 1MΩ.
Process control	Keep the liquid mixing proportion when many phases are mixed Control flow rate of oils as appropriate.
Pipeline with good electrical conductivity	Use medal pipeline with good grounding property. Use nonmetallic pipeline with electrically conductive function.
Use antistatic additives	Add anti-static additives in oils with low conductivity.
Electrostatic mitigation	Give three times of relaxation time to oils.
Static elimination	Passive static eliminator. Active static eliminator.

中国石化 SINOPEC

Thank you!

黄建华

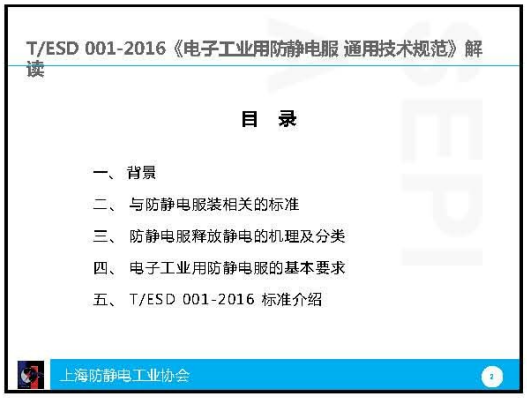
黄建华，上海防静电工业协会理事长，中国制冷空调工业协会洁净室技术委员会理事，全国洁净室及相关受控环境标准化技术委员会（ SAC/TC 319）委员，全国电磁屏蔽材料标准化技术委员会（ SAC/TC 323）副主任委员。上海晨隆国际贸易有限公司、上海晨隆静电科技有限公司、上海晨隆纺织新材料有限公司董事长。中国首批洁净室工程师、防静电高级工程师。主持编写的国家标准及行业标准有 GB/T 24249-2009《防静电洁净织物》、GB/T 30131-2013《纺织品 服装系统静电性能的评定 穿着法》、 FZ/T 80014-2012《洁净室服装 通用技术规范》、 FZ/T 80013-2012《洁净室服装 易脱落大颗粒物测试方法》、 FZ/T 80012-2012《洁净室服装 电阻测试方法》。参与编写的国家标准有 GB/T 25915.5-2010《洁净室及相关受控环境 第五部分 ：运行》、GB/T 26667-2011《电磁屏蔽材料 术语》、 GB/T 30139-2013《工业用电磁屏蔽织物通用技术要求》、 GB/T 30142-2013《平面型电磁屏蔽材料屏蔽效能测试方法》。目前正在主持编写的国家标准有 ： GB/T《纺织品 静电性能的评定 静电衰减法》。

Huang Jianhua

Huang Jianhua is chairman of Shanghai Electrostatic Protective Industrial Association, director of Clean-room Technology Committee of China Refrigeration and Air Conditioning Industry Association, director of national clean-room and controlled environment for Standardization Technical Committee（SAC/TC 319）, and vice chairman of electromagnetic shielding materials Standardization Technical Committee（SAC/TC 323）.

He is chairman of Shanghai Chen Long International Trade Co., Ltd., Shanghai Chen Long Electrostatic Technology Co., Ltd. and Shanghai Chen Long textiles and new materials Co., Ltd. Huang is also one of the first clean-room engineers and senior engineers on anti-electrostatic. Huang presided and complied the national standard GB/T 24249-2009 “anti-electrostatic clean-room fabric”, GB/T 30131-2013 “evaluation of the electrostatic properties of textile and apparel dressing method”, FZ/T 80014-2012 “general technical specification of clean-room garment”, FZ/T 80013-2012 “testing method of easily fall off large particulate matter clean-room garments”, FZ/T 80012-2012 “resistance testing methods of clean-room garments”. He involved in the compilation of the national standard GB/T 25915.5-2010 “clean-room and controlled environments associated, Part V: Run” and GB/T 26667-2011 “electromagnetic shielding material: terms”, GB/T 30139-2013 “shielding effectiveness test method of planar electromagnetic shielding material”. Now he is presiding and compiling the national standard: GB/T “evaluation of the electrostatic properties of textile and apparel: electrostatic decay method”.


T/ESD 001-2016《电子工业用防静电服
通用技术规范》解读
上海防静电工业协会
黄建华
2016年11月17日
上海防静电工业协会


T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读
目 录
一、背景
二、与防静电服装相关的标准
三、防静电服释放静电的机理及分类
四、电子工业用防静电服的基本要求
五、T/ESD 001-2016 标准介绍
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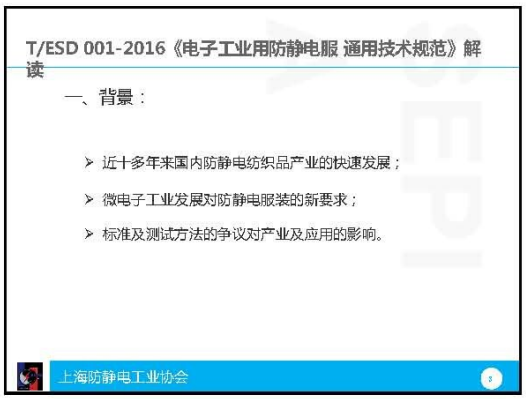
T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读
一、背景：
近十多年来国内防静电纺织品产业的快速发展；
微电子工业发展对防静电服装的新要求；
标准及测试方法的争议对产业及应用的影响。
上海防静电工业协会
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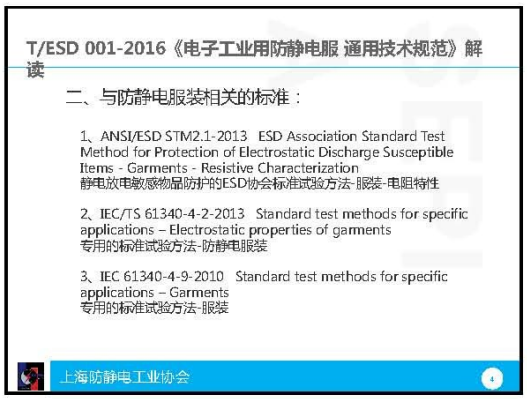
T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读
二、与防静电服装相关的标准：
1、ANSI/ESD STM2.1-2013 ESD Association Standard Test Method for Protection of Electrostatic Discharge Susceptible Items - Garments - Resistive Characterization
静电放电敏感物品防护的ESD协会标准试验方法-服装-电阻特性
2、IEC/TS 61340-4-2-2013 Standard test methods for specific applications – Electrostatic properties of garments
专用的标准试验方法-防静电服装
3、IEC 61340-4-9-2010 Standard test methods for specific applications – Garments
专用的标准试验方法-服装
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二、与防静电服装相关的标准：
4、JIS T8118-2001 Working wears for preventing electrostatic hazards
静电危害防护工作服
5、GB 12014-2009 静电服
6、GB/T 23316-2009 工作服 防静电性能的要求及试验方法
7、FZ/T 80014-2012 洁净室服装 通用技术规范
8、SJ/T 11412-2010 防静电洁净工作服及织物通用规范
9、GB/T 22042-2008 服装 防静电性能 表面电阻率试验方法
10、GB/T 22043-2008 服装 防静电性能 通过材料的电阻（垂直电阻）试验方法
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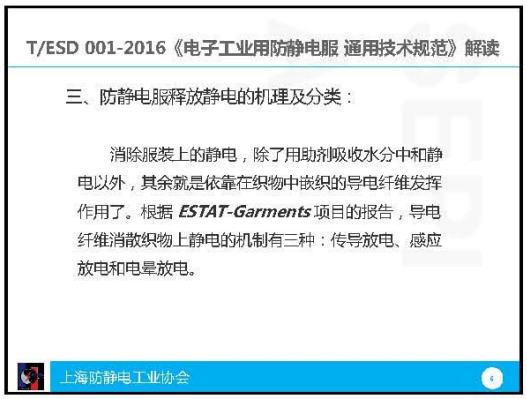
T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读
三、防静电服释放静电的机理及分类：
消除服装上的静电，除了用助剂吸收水分中和静电以外，其余就是依靠在织物中嵌织的导电纤维发挥作用了。根据 ESTAT-Garments 项目的报告，导电纤维消散织物上静电的机制有三种：传导放电、感应放电和电晕放电。
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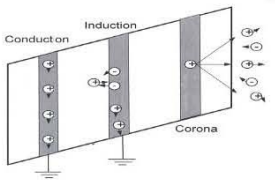
三、防静电服释放静电的机理及分类：



防静电服的三种静电消散机制

T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读

三、防静电服释放静电的机理及分类：

防静电工作服根据其使用环境及技术特征可分为如下三类：

类别	技术特征		主要放电机制	作用	典型应用行业
	静电要求	洁净要求			
A类 易燃易爆行业	是	否	电晕	防止静电放电引发安全事故	石油、化工、火工品
B类 微电子工业	是	否	接地感应	防止静电放电对ESDS的损害以及EMI干扰	SMT
C类 洁净室及相关受控环境	是	是	电晕 接地感应	防止静电极附灰尘影响产品质量以及静电放电可能对产品（如半导体）的损害	医药、食品、半导体

请注意：不是所有防静电服装都适用 GB 12014

T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读

四、电子工业用防静电服的基本要求：

电子工厂中防静电工作服是在静电放电保护区（EPA）中穿着的，其目的是通过接地释放的方式最小化带电衣物对敏感电子产品进行静电放电的故障风险，服装的防静电技术要求取决于EPA中静电敏感元器件（ESDS）对人体模型（HBM）及带电器件模型（CDM）的静电放电的敏感度。

T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读

四、电子工业用防静电服的基本要求：

EPA中因带电服装所致的ESD故障：

1、因带电服装的静电场感应而导致ESDS带电，并发生场强感应型CDM类型的放电。

2、因带电服装与ESDS直接接触（特别是袖子部位）而引发的近似HBM类型的放电。

因此，电子工业用防静电服静电性能的考核指标是：

系统电阻和服装表面的**静电电压**（摩擦起电）

T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读

五、T/ESD 001-2016 标准介绍：

1、范围

本标准规定了电子工业用防静电服的功能原理、技术指标、检测方法、检验规则、标识、包装、运输、贮存的要求。

本标准适用于防止静电对静电放电敏感器件造成直接或间接损伤的工作服。

本标准不适用于易燃易爆场所穿用的防静电服。

T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读

五、T/ESD 001-2016 标准介绍：

2、功能原理

电子工业用防静电服通常使用防静电织物缝制而成，通过某些特定工艺使服装上任意两个裁片之间的电阻小于一定范围，并在服装上设置合适的可接地点，通过有效的接地方式释放服装表面可能积累的静电。其中有效的接地方式包括但不限于：

——通过服装袖口与已接地人员的皮肤紧密接触，实现间接接地；

——通过服装上的布料与已接地人员的皮肤直接接触，实现间接接地；

——通过服装上的布料与已接地的防静电座椅紧密接触，实现间接接地；

——在服装上设置接地组件，通过接地电缆直接接地。

T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读

五、T/ESD 001-2016 标准介绍：

3、技术指标

3.1、一般物性

3.1.1、基本安全性能

基本安全性能应符合GB 18401的要求。

3.1.2、外观缝制质量

服装外观应无破损、斑点、污物以及其他影响穿用性能的缺陷。

服装各部位缝制线路顺直、整齐、平服牢固。上下松紧适宜，无跳针、断针，起落针处应有回针。

缝制针距：（12~14）针/3 cm（单位面积质量≥200g/m²），（14~16）针/3 cm（单位面积质量＜200g/m²）。

T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读

五、T/ESD 001-2016 标准介绍：

3.1.3、尺寸变化率

尺寸变化率应符合表1的要求

表1 尺寸变化率指标

测试项目	尺寸变化率 %
领大	≥ -2.5
胸围	≥ -2.5
后衣长	≥ -3.5
腰围	≥ -2.0
裤腿长	≥ -3.5

T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读

五、T/ESD 001-2016 标准介绍：

3.2、静电性能

静电性能指标应符合表2的要求。

表2 静电性能指标

项目	要求		
	A级	B级	C级
系统电阻 R/ Ω	$1.0\times10^5 \le R < 3.5\times10^7$	$< 1.0\times10^9$	$< 1.0\times10^{11}$
摩擦起电电压/ V	＜100	＜500	＜1000

T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读

五、T/ESD 001-2016 标准介绍：

4、检测环境

检测的环境条件分为基准条件和一般条件，具体参数见表A.1。一般情况下，基准条件下的检测结果更具备代表性。

表A.1 检测环境的具体参数

条件	温度 / ℃	相对湿度 / %
基准条件	23±3	12±3
一般条件	23±3	50±5

T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读

五、T/ESD 001-2016 标准介绍：

样品洗涤

洗涤程序按GB/T 8629-2001的4A程序洗涤3次。使用其他洗涤程序和次数时，应在试验报告中注明。

样品前处理

将试样在50℃±5℃下滚筒烘干1h。

在检测环境条件下静置24h。

在试样处理过程和检测过程中，应注意避免人为因素对试样的干扰。

如：人员在触摸试样时应戴塑胶手套（或采取其他防护措施）

T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读

五、T/ESD 001-2016 标准介绍：

5、系统电阻检测方法

通过两个电极分别连接服装可接地点和服装表面任意一点，在电极上加载直流电，测定服装的表面任一点到可接地点之间的电阻。

—当袖口作为可接地点时，将柱电极放置在袖口的内表面；

—当服装上的布料直接作为可接地点时，将柱电极放置在布料与人员皮肤直接接触的位置；

—当服装的下摆作为可接地点时，将柱电极放置于服装下摆与防静电座椅接触的位置；

—当服装上设置专门的可接地组件时，将测试线直接连接在接地组件上。

T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读

五、T/ESD 001-2016 标准介绍：

6、摩擦起电电压检测方法

对服装表面进行规定的摩擦后，使用非接触式电压测试仪测试其起电电压的数值。

6.1、仪器装置

6.1.1、非接触电压测试仪，测试范围包含0V~±2000V，测试精度不低于±5%。

6.1.2、接地的防静电工作台面，系统电阻值为$1.0\times10^5\Omega$~$1.0\times10^9\Omega$。

6.1.3、摩擦布为纯棉材质，测试前须与试样共同调湿。如果使用其他材质的摩擦布，需在报告中注明。

T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读

五、T/ESD 001-2016 标准介绍：

6.2、检测程序

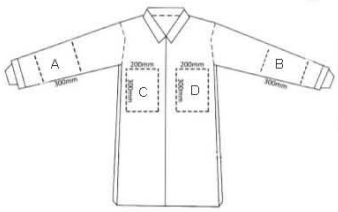
对服装表面进行规定的摩擦后，使用非接触式电压测试仪测试其起电电压的数值。

6.2.1、将非接触式电压测试仪接地，并按说明书进行调零，备用。

6.2.2、将试样按图进行标记，然后将拉链或纽扣打开，内表面朝下，平铺于防静电台面上。

T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读

五、T/ESD 001-2016 标准介绍：



T/ESD 001-2016《电子工业用防静电服 通用技术规范》解读

五、T/ESD 001-2016 标准介绍：

6.2.3、测试人员应穿着合适的防静电服装以防止对测试结果造成干扰。

6.2.4、在服装表面选取A、B、C、D部位作为测试点，手持摩擦布以适当力度，进行单向摩擦20次，摩擦速度为1次/s。

6.2.5、摩擦结束后，用经过调零的非接触式电压测试仪迅速对准服装被摩擦区域的中心部位，注意按仪器说明书的要求保持其探头与被测部位的距离，读出1.5s±1s内的最大电压值并记录。

6.2.6、以所有结果的最大值作为最终检测结果。

介绍完毕

敬请批评指正！

上海防静电工业协会
Shanghai Electrostatic Protective Industrial Association
E-mail: 1366147428@qq.com


Interpretation of T/ESD001-2016
Static Control Garment for Electronic Industry
- General Technical Regulations
Shanghai Electrostatic Protective Industrial Association
Huang Jianhua
Nov. 17, 2016
Shanghai Electrostatic Protection Industrial Association


Interpretation of T/ESD001-2016 Static Control Garment for Electronic Industry - General Technical Regulations
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Shanghai Electrostatic Protective Industrial Association
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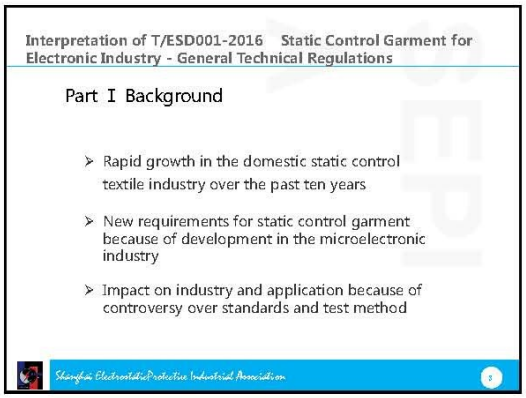
Interpretation of T/ESD001-2016 Static Control Garment for Electronic Industry - General Technical Regulations
Part I Background
Rapid growth in the domestic static control textile industry over the past ten years
New requirements for static control garment because of development in the microelectronic industry
Impact on industry and application because of controversy over standards and test method
Shanghai Electrostatic Protective Industrial Association
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Interpretation of T/ESD001-2016 Static Control Garment for Electronic Industry - General Technical Regulations
Part II Related Standards on Static Control Garment
1. ANSI/ESD STM2.1-2013 ESD Association Standard Test Method for Protection of Electrostatic Discharge Susceptible Items - Garments - Resistive Characterization
静电放电敏感物品防护的ESD协会标准试验方法-服装-电阻特性
2. IEC/TS 61340-4-2-2013 Standard test methods for specific applications – Electrostatic properties of garments
专用的标准试验方法-防静电服装
3. IEC 61340-4-9-2010 Standard test methods for specific applications – Garments
专用的标准试验方法-服装
Shanghai Electrostatic Protective Industrial Association
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Interpretation of T/ESD001-2016 Static Control Garment for Electronic Industry - General Technical Regulations
Part II Related Standards on Static Control Garment
4. JIS T8118-2001 Working wears for preventing electrostatic hazards
静电危害防护工作服
5. GB 12014-2009 Static protective clothing
防静电服
6. GB/T 23316-2009 Anti-static requirement and test methods of working clothing
工作服 防静电性能的要求及试验方法
7. FZ/T 80014-2012 Cleanroom garment-General technical regulations
洁净室服装 通用技术规范
8. SJ/T 11412-2010 General specification for antistatic and cleanroom garment and fabric
防静电洁净工作服及织物通用规范
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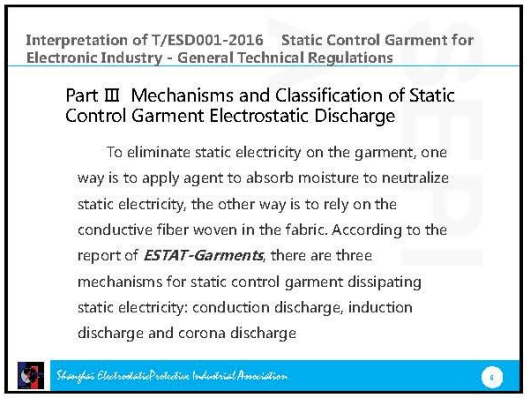
Interpretation of T/ESD001-2016 Static Control Garment for Electronic Industry - General Technical Regulations
Part III Mechanisms and Classification of Static Control Garment Electrostatic Discharge
To eliminate static electricity on the garment, one way is to apply agent to absorb moisture to neutralize static electricity, the other way is to rely on the conductive fiber woven in the fabric. According to the report of ESTAT-Garments, there are three mechanisms for static control garment dissipating static electricity: conduction discharge, induction discharge and corona discharge
Shanghai Electrostatic Protective Industrial Association
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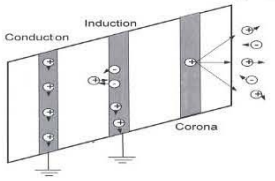
Part Ⅲ Mechanisms and Classification of Static Control Garment Electrostatic Discharge



Three mechanisms of static control garment dissipating static electricity

Part Ⅲ Mechanisms and Classification of Static Control Garment Electrostatic Discharge

Static control garment can be classified to the following three categories based on its application environment and technical features.

Category	Technical feature		Main discharge mechanism	Aim	Typical application environment
	Static control requirement	Cleanness requirement			
A Flammable and explosive industry	Yes	No	Corona	Prevent safety accident caused by electrostatic discharge	Petroleum, chemical and initiating explosive device
B Microelectronic industry	Yes	No	Conduction Induction	Prevent damage to ESDS and interference to EMF caused by electrostatic discharge	SMT
C Cleanroom and related controlled environment	Yes	Yes	Corona Conduction Induction	Prevent quality compromise caused by static electricity absorbing dust and potential damage to product (semiconductor) caused by electrostatic discharge	Medical, food and semiconductor

Attention: GB 12014 is not applicable to all static control garment

Part IV Basic Requirements on Static Control Garment for Electronic Industry

In electronic factory, static control garment is worn in EPA. Its purpose is to minimize the risk of damaging SSD when electrostatic discharge happens in charged garment by grounding discharge. Technical requirements of garment depends on how sensitive ESDS in EPA is to electrostatic discharge of HBM and CDM

Part IV Basic Requirements on Static Control Garment for Electronic Industry

ESD failure in EPA caused by charged garment

1. ESDS is charged from charged garment electrostatic field induction and field-induction CMD electrostatic discharge.
2. Direct contact happens between charged garment (esp. sleeve) and ESDS and results in electrostatic discharge similar to HBM type.

So, indicators for static control garment performance appraisal are:
System resistance and garment surface **electrostatic voltage** (triboelectric voltage)

Part V Introduction of T/ESD 001-2016

1. Scope

The Standard specifies requirements on static control garment used in electronic industry regarding functional principles, technical index, test method, test rules, signs, packaging, transporting and storing.

The Standard applies to garment preventing direct or indirect damage to ESDS caused by electrostatic discharge.

The Standard is not applicable to garment used in flammable and explosive environment

Part V Introduction of T/ESD 001-2016

2. Functional principle

Static control garment for electronic industry normally is made of antistatic fabric, making resistance between any two cut-part is lower than a certain range through some special process. Proper grounding point is set in the garment and potential static electricity generated on the garment surface can be effectively dissipated through grounding discharge. Effective grounding methods include but not limited to:

——Through close contact between the garment sleeve end and skin of the grounding personnel and realize indirect grounding.
——Through direct contact between the garment fabric and skin of the grounding personnel and realize indirect grounding.
——Through close contact between the garment fabric and grounding antistatic chairs to realize indirect grounding.
——Set grounding assembly on the garment and ground directly through grounding cord.

Part V Introduction of T/ESD 001-2016

3. Technical index

3.1. General material property

3.1.1. Basic safety performance

Basic safety performance conforms to requirements of GB 18401.

3.1.2. Sewing quality in appearance

Garment appearance has no damage, stain, dirt or other flaw affecting usage performance.

Each part of garment sewing line is straight, neat, smooth, flat and firm. From top to bottom, proper degree of tightness is required, no skip stitch and broken stitch, back stitch is required on the first and last stitch.

Stitch distance: (12~14) stitches/3 cm (unit area mass≥200g/m^2) , (14~16) stitches/3 cm (unit area mass ＜200g/m^2) 。

Part V Introduction of T/ESD 001-2016

3.1.3. Dimensional change rate

Dimensional change rate conforms to requirements of Table 1

Table 1 Dimensional change rate index

Test item	Dimensional change rate %
Collar	≥ -2.5
Chest width	≥ -2.5
Back length	≥ -3.5
Waist width	≥ -2.0
Trousers length	≥ -3.5

Part V Introduction of T/ESD 001-2016

3.2. Static control performance

Static control performance conforms to requirements of table 2

Table 2 Static control performance index

Item	Index		
	Class A	Class B	Class C
System resistance / Ω	$1.0\times10^5 \le R < 3.5\times10^7$	$<1.0\times10^9$	$<1.0\times10^{11}$
Triboelectric voltage/ V	＜100	＜500	＜1000

Part V Introduction of T/ESD 001-2016

4. Test environment

Conditions of test environment is divided to benchmark condition and average condition. See detail parameters in Table A.1. Normally test result of benchmark condition is more representative.

Table A.1 Detailed parameters of test environment

Condition	Temperature/ ℃	Relative Humidity/ %
Benchmark condition	23±3	12±3
Average condition	23±3	50±5

Part V Introduction of T/ESD 001-2016

Sample laundering

Laundering is done three times in accordance with 4A process in GB/T 8629-2001. It should be indicated in the test report if other laundering process and times is applied.

Sample pretreatment

Dry the sample in the drum 50℃±5℃ for 1h.

Leave it in the test environment condition for 24h.

During the process of sample treatment and sample testing, human factor interference to the sample should be avoided.

Eg.: Personnel should wear rubber gloves when touching sample(or take other preventive measures)

Part V Introduction of T/ESD 001-2016

5. Test method for system resistance

By connecting garment grounding point and a random point on the garment surface through two electrodes, applying direct current on the electrodes, to test resistance between garment surface random point and grounding point.

—When sleeve end is the grounding point, put the electrode on the inner surface of the sleeve end.

—When fabric of the garment is the grounding point, put the electrode on the place where fabric and personnel skin contact directly

—When garment hem is the grounding point, put the electrode on the place where garment hem and esd chairs contact

—When special grounding assembly is set on the garment, connect the testing line to the assembly directly.

Interpretation of T/ESD001-2016 Static Control Garment for Electronic Industry - General Technical Regulations

Part V Introduction of T/ESD 001-2016

6. Test method for testing triboelectric voltage

After applying specified friction on the garment surface, use non-contact voltage meter to test the value of its triboelectric voltage.

6.1. Device and apparatus

6.1.1. Non-contact voltage meter. Test range 0V~±2000V and test accuracy is not lower than ±5%。

6.1.2、Grounding ESD work table. System resistance $1.0\times10^5\Omega$~$1.0\times10^9\Omega$.

6.1.3. Rubbing cloth is pure cotton cloth. Conditioning should be done together with sample before test. It should be indicated in the report if cloth of other material is used.

Interpretation of T/ESD001-2016 Static Control Garment for Electronic Industry - General Technical Regulations

Part V Introduction of T/ESD 001-2016

6.2. Test process

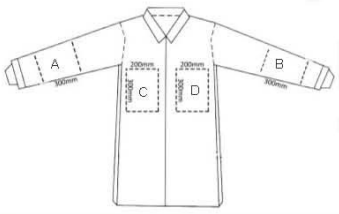
After applying specified friction on the garment surface, use non-contact voltage meter to test the value of its triboelectric voltage

6.2.1. Ground the non-contact voltage meter, adjust it to zero according to the manual before use.

6.2.2. Mark the sample according to the sketch, unzipper or unbutton it, place it flat on the ESD work table with its inner surface facing down

Interpretation of T/ESD001-2016 Static Control Garment for Electronic Industry - General Technical Regulations

Part V Introduction of T/ESD 001-2016



Interpretation of T/ESD001-2016 Static Control Garment for Electronic Industry - General Technical Regulations

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6.2.3. Tester should wear proper static control garment to prevent interference to the test result.

6.2.4. Select A、B、C、D part on the garment surface as testing points, apply , handheld rubber cloth and rub 20 time in a single direction with proper strength. Rubbing speed is 1 time/s.

6.2.5. When rubbing is done, quickly aim the adjusted non-contact voltage meter to the center of rubbed area on the garment. Pay attention to the requirement specified in the manual on distance kept between probe and the tested part, read the max voltage and record in 15s±1s.

6.2.6. Take maximum values as the final test results.

Thank you for listening

Your comment is welcome!

Shanghai Electrostatic Protective Industrial Association

E-mail: 1366147428@qq.com

参会代表名单

Attendee List

参会代表名单/Attendee List

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33	Shenzhen Best-Resource Counseling Co Ltd	Jinyun Peng		Email:pengjinyun@esd-resource.com
34	I-Con Tech International Inc.	Jerry Rivera		Tel: 632-553-3915 Email:jerry.rivera@icontechph.com
35	Finisar Corporation	Jeffrey Salisbury		Tel: 214-509-2872 Email:jeffrey.salisbury@finisar.com
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Seq. No.	Organization 单位名称	Name 姓名	Title 职务	Contact 联络方式
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54	China Academy of Space Technology (CAST) 中国空间技术研究院	Fan Yanping 范燕平	Vice-Minister /Researcher 副部长/研究员	
55	Beijing Orient Institute of Measurement and Test 北京东方计量测试研究所	Xu Siwei 徐思伟	President 所长	
56	Beijing Orient Institute of Measurement and Test 北京东方计量测试研究所	Su Xinguang 苏新光	Vice-President 副所长	
57	Beijing Orient Institute of Measurement and Test 北京东方计量测试研究所	Ma Zhiyi 马志毅	Researcher 研究员	
58	Shaanxi Provincial Office of Science and Technology for National Defense 陕西省国防科技工业办公室	Yang Yuping 杨玉萍	Chief Engineer 总工程师	
59	Academy of Space Electronic Information Technology 中国空间技术研究院西安分院	Li Jun 李军	President 院长	
60	Xi'an Modern Chemistry Research Institute 西安近代化学研究所	Lu Dianlin 陆殿林	Vice-President 副所长	
61	Xi'an Modern Chemistry Research Institute 西安近代化学研究所	Zhang Gao 张皋	Chief Engineer/Researcher 总工程师/研究员	
62	China Academy of Space Technology (CAST) 中国空间技术研究院	Wang Zhiyong 王志勇	Director Senior Engineer 处长/高工	

Seq. No.	Organization 单位名称	Name 姓名	Title 职务	Contact 联络方式
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93	China Standardization Press 中国标准化杂志社	Sun Xiaoli 孙晓立	Journalist 记者	
94	China's Electronic Instrument Industry Association Anti-static Equipment Branch 中国电子仪器行业协会防静电装备分会	Tan Huixin 谭慧新	Secretary General 秘书长	Email: thx01@sina.com

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96	Shanghai Electrostatic Protective Industrial Association 上海防静电工业协会	Sun Juntong 孙君同	Secretary-General 秘书长	
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99	Xi'an Modern Chemistry Research Institute 西安近代化学研究所	Su Pengfei 苏朋飞	Senior Engineer 高工	
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107	Shanghai Pousto Electronic Engineering Co., Ltd. 上海佰斯特电子工程有限公司	Yan Ping 阎平	Partner of Pousto 佰斯特合作伙伴	
108	YIYUAN Electronic Technology Co., Ltd 一远静电科技有限公司	Fan Hao 樊昊	Manager 经理	
109	YIYUAN Electronic Technology Co., Ltd 一远静电科技有限公司	Zhai Jianbing 翟建兵	Manager 经理	
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123	Chinese Academy of Sciences Institute of Electronics 中科院电子所	Liu Hong 柳宏	Senior Engineer 高级工程师	
124	Chinese Academy of Sciences Institute of Electronics 中科院电子所	Ji Qilin 计启林	Senior Engineer 高级工程师	
125	The Institute of Atmospheric Physics, Chinese Academy of Sciences 中国科学院大气物理研究所	Lu Gaopeng 陆高鹏	Rresearcher 研究员	Email:gaopenglu@gmail.com
126	Changchun Institute of Optics,Fine Mehcanics and Physics,Chinese Academy of Sciences 中科院长春光机所	Zhang Xueli 张雪莉	Process Engineer 工艺工程师	
127	State Key Laboratory of Transducer Technology, Institute of Electronics, Chinese Academy of Sciences 中国科学院电子学研究所传感技术联合国家重点实验室	Xia Shanhong 夏善红	Researcher 研究员	
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170	Beijing Xinhuahangyu Trading Company 北京欣华航宇商贸有限公司	Zheng Fang 郑芳	Chief of Operations 业务主管	Fax:57863072 Email:1732970273@qq.com
171	Xi'an Xidian High-Voltage Switch LLC 西安西电高压开关有限责任公司	Ma Liang 马亮	Head of Design 设计主管	Email: maliang06@126.com
172	Shenzhen Zhongming Science and Technology Development Co., Ltd. 深圳市中明科技开发有限公司	Hu Zhongwei 胡忠伟	Research and Development Manager 研发经理	Tel: 0755-29461997 Fax: 0755-29461361 Email: huzhongwei@horb.com.cn
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174	Shanghai Baijie Electrostatic Detection Technology Center 上海佰洁静电检测技术中心	Xu Ming 徐明	Director 主任	Fax: 021-58898195 Email: xm@esdtest.org
175	Shanghai Chenlong Electrostatic Technology Co., Ltd 上海晨隆静电科技有限公司	Wei Xiaobo 魏晓波	General Manager 总经理	Tel: 021-51035035 Fax: 021-58898195 Email: Sharron@esdworld.com
176	Shanghai Huafei Electrostatic Protection Products Co., Ltd 上海华菲静电防护产品有限公司	Su Hua 苏骅	General Manager 总经理	Tel:021-58167415 Fax:021-58167412 Email：suhua@huafei-sc.com
177	Shanghai New-Era Technology Development Co., Ltd. 上海创纪科技发展有限公司	Bi Gexiong 毕戈雄	General Manager 总经理	Tel:32060161 Fax:62047075 Email:13801951041@139.com
178	Xiamen Xiangyukanghui Technology Co. Ltd 厦门象屿康惠科技有限公司	Li Youdong 李有冬	General Manager 总经理	Tel:0592-7393150 Fax: 0592-5627506

Seq. No.	Organization 单位名称	Name 姓名	Title 职务	Contact 联络方式
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180	Xiamen Xiangyukanghui Technology Co. Ltd 厦门象屿康惠科技有限公司	Wang Yuan 王渊	Manager 经理	Tel:0592-7393150 Fax: 0592-5627506
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182	Huangshan Jiameiqi Application Research Institute of Coatings 黄山佳美奇涂料应用研究所	Wang Yifei 王一飞	Manager/ Director 经理/所长	Tel: 0559-2524831 Fax: 0559-2524931
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185	Zhongdian Exhibition & Information Communication Co., Ltd 中电会展与信息传播有限公司	He Qionghua 贺琼华	Manager 经理	Fax: 010-53216092
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187	Chinese Flight Test Establishment 中国飞行试验研究院	Liu Hongmei 刘红梅	Senior Engineer 高工	
188	Chinese Flight Test Establishment 中国飞行试验研究院	Wang Chao 王超	Senior Engineer 高工	

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190	Shandong Chambroad Petrochemicals Co., Ltd. 山东京博石油化工有限公司	Wu Huanhuan 吴欢欢	Security Officer 安全员	Email:351443991@qq.com