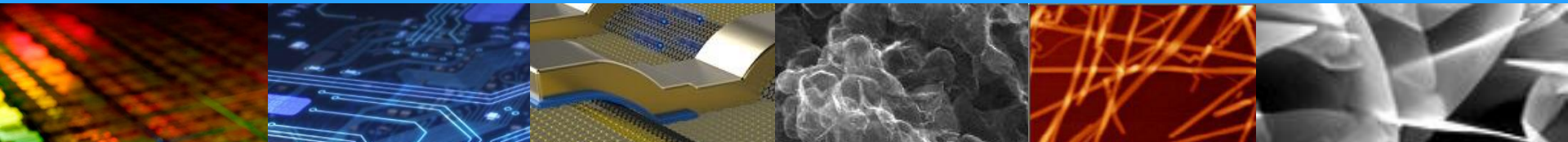# ISO/TC 229 Nanotechnologies – standardisation activities in graphene and related 2D materials

Charles Clifford, Surface Technology Group,

National Physical Laboratory

UK head of delegation to ISO TC229

charles.clifford@npl.co.uk

ISO/TC 229 Nanotechnologies Structure

37 P members, 14 O members,
27 internal liaisons, 11 external liaisons
Secretariat: UK: Chairman: Denis Koltsov (UK)

JWG 1   Terminology and Nomenclature (Canada)

JWG 2   Measurement and Characterization (Japan)

WG 3   Health, Safety and Environment (USA)

WG 4   Material Specification (China)

WG5   Products and Applications (Korea)

NLCG   Liaison coordination group

TG2   Consumer and societal dimensions of nanotechnologies

TG3   Nanotechnologies and sustainability

61 published documents (~9 in 2017) and 35+ under development

Meeting twice yearly: interim WGs in Spring (Ottawa and London)
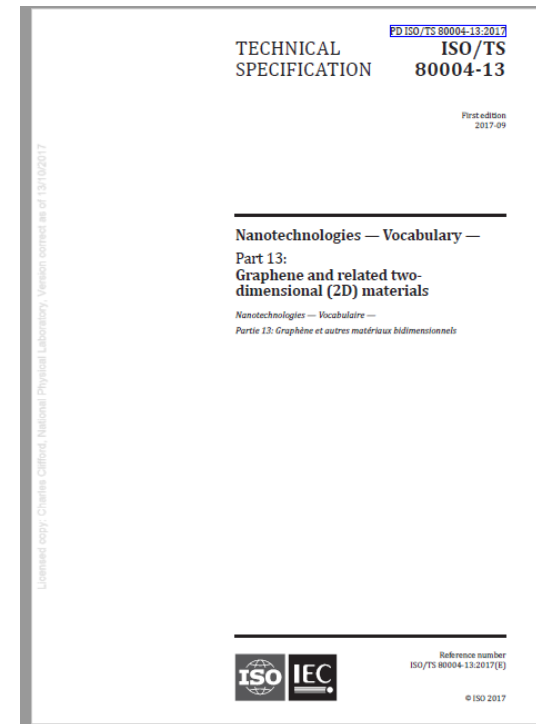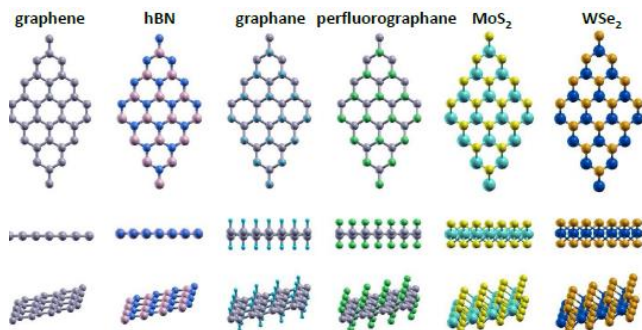**Plenary: 29 Oct – 2 Nov 2018, Malaysia**

TS 80004-13 - Nanotechnologies -- Vocabulary -- Part 13: Graphene and related two dimensional materials

Published September 2017

99 Terms and definitions:

- related to materials
- methods for producing 2D materials
- characterizing 2D materials
- 2D materials characteristics

Freely available on ISO OBP

TECHNICAL SPECIFICATION

ISO/TS 80004-13

PD ISO/TS 80004-13:2017

First edition 2017-09

Nanotechnologies — Vocabulary —

Part 13:
Graphene and related two-dimensional (2D) materials

Nanotechnologies — Vocabulaire —
Partie 13: Graphène et autres matériaux bidimensionnels

Reference number
ISO/TS 80004-13:2017(E)

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2D materials Terminology Standard

NPL
National Physical Laboratory

3.1.1.1
two-dimensional material
2D material
material, consisting of one or several layers with the atoms in each layer strongly bonded to neighbouring atoms in the same layer, which has one dimension, its thickness, in the nanoscale or smaller and the other two dimensions generally at larger scales

Note 1 to entry: The number of layers when a two-dimensional material becomes a bulk material varies depending on both the material being measured and its properties. In the case of graphene layers, it is a two-dimensional material up to 10 layers thick for electrical measurements, beyond which the electrical properties of the material are not distinct from those for the bulk [also known as graphite].
Note 2 to entry: Interlayer bonding is distinct from and weaker than intralayer bonding.
Note 3 to entry: Each layer may contain more than one element.
Note 4 to entry: A two-dimensional material can be a nanoplate.

3.1.2.1
graphene
graphene layer
single layer graphene
monolayer graphene
single layer of carbon atoms with each atom bound to three neighbours in a honeycomb structure

Note 1 to entry: It is an important building block of many carbon nano-objects.
Note 2 to entry: As graphene is a single layer, it is also sometimes called monolayer graphene or single layer graphene and abbreviated as 1LG to distinguish it from bilayer graphene (2LG) and few-layered graphene (FLG).
Note 3 to entry: Graphene has edges and can have defects and grain boundaries where the bonding is disrupted.

3.1.2.10
few-layer graphene
FLG
two-dimensional material consisting of three to ten well-defined stacked graphene layers

3.1.2.13
graphene oxide
GO
chemically modified graphene prepared by oxidation and exfoliation of graphite, causing extensive oxidative modification of the basal plane

Note 1 to entry: Graphene oxide is a single-layer material with a high oxygen content, typically characterized by C/O atomic ratios of approximately 2,0 depending on the method of synthesis.

4 Abbreviated terms

1L	monolayer/single-layer
1LG	monolayer/single-layer graphene
2D	two-dimensional
2L	bilayer
2LG	bilayer graphene
3L	trilayer
3LG	trilayer graphene
CVD	chemical vapour deposition
FL	few-layer
FLG	few-layer graphene
GNP	graphene nanoplatelet
GO	graphene oxide
hBN	hexagonal boron nitride
rGO	reduced graphene oxide

DTR 19733 Matrix of properties and measurement techniques for graphene and related 2D materials

Led by Korea (Clare Byeon) and USA (A Hight- Walker)

Properties		AFM	KPFM	BET	EPMA	ESR (EPR)	ICP-MS	LEEM	Optical Microscopy	Raman	UV-VIS-NIR Spectroscopy	SEM	SIMS	STM	TEM	UPS	XPS	TGA	Combustion	Titration	4-point Porbe	Hall Bar
Structural	Number of Layers	○						○	○	○	○				○							
	Thickness	○						○							○							
	Stacking Angle									○				○	○							
	Flake Size	○							○	○		○			○							
	Domain (grain) Size	○							○	○	○			○	○							
	Surface Area			○							○											
	Crystal Defect	○			○	○				○		○		○	○							
Chemical	Non-Graphene Contents & Residue									○			○				○	○	○			
	Oxygen Contents				○								○				○	○		○		
	Metal Contents				○		○						○				○					
Mechanical	Modulus	○								○												
Thermal	Thermal Conductivity									○												
Optical	Transmittance								○		○											
Electrical/ Electronic	Sheet Resistance																				○	○
	Mobility																				○	○
	Charge Carrier Concentration		○																		○	○
	Work Function		○													○						

Draft technical report

Properties and techniques described

Currently out for DTR ballot (closes end April)

ISO PWI 21356-1 Structural Characterisation of Graphene from powders and dispersions
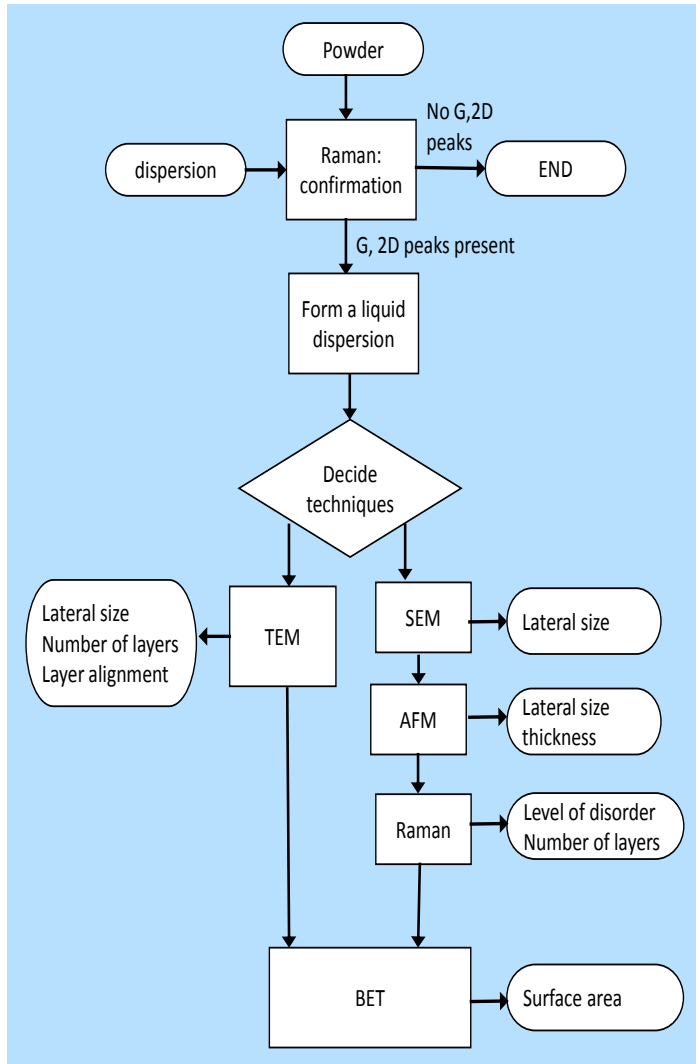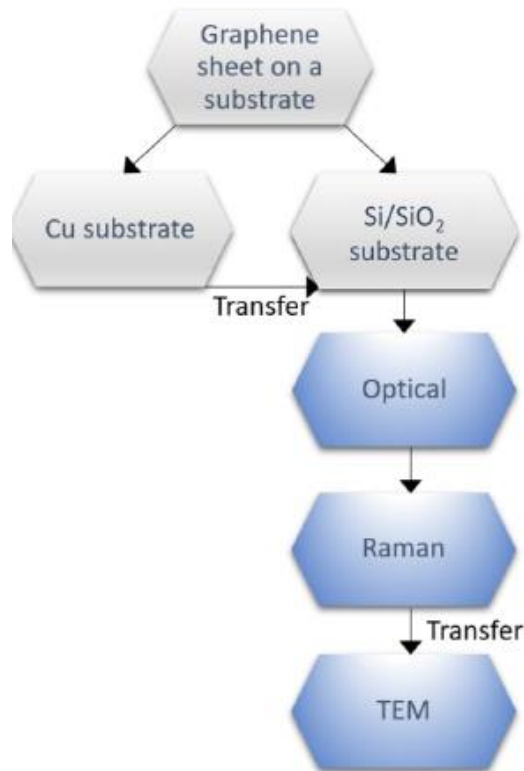

- Led by UK (C Clifford, A Pollard)
- order of methods for characterising the structural properties of graphene from powders and dispersions
- properties covered are the number of layers (thickness), lateral flake size, the level of disorder, layer stacking and specific surface area. Suggested measurement protocols, sample preparation routines and data analysis given.
- Currently out for New work item ballot
- Technical experts and comments requested

Nanotechnologies -- Chemical characterisation for graphene in powders and suspensions

Provisional work item led by UK (C Clifford and China (LL Ren)
Include sample preparation, protocols and data analysis
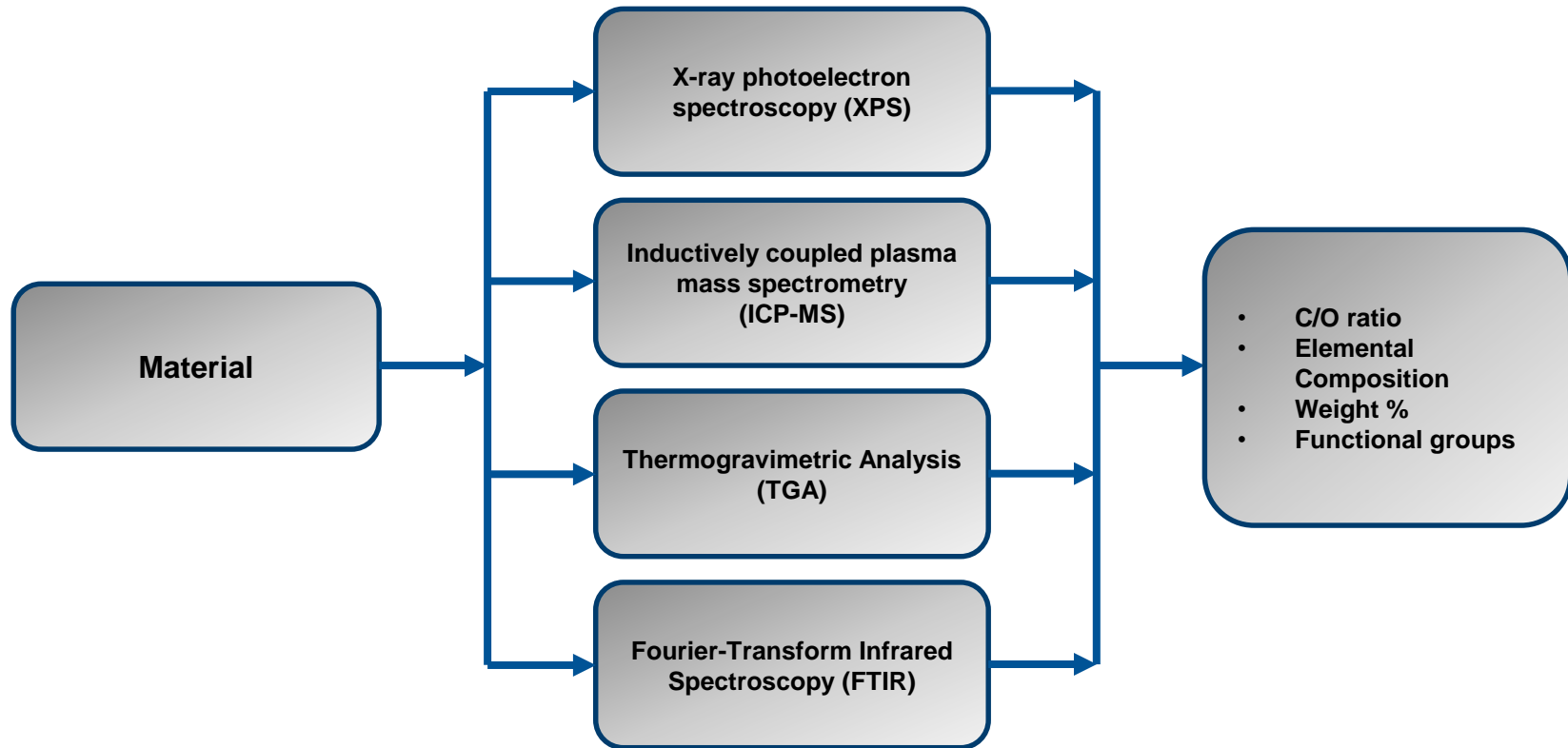
Future possible PWI 21356-2 Structural Characterisation of CVD grown Graphene

- Proposal led by UK (C Clifford, A Pollard)
- order of methods for characterising the structural properties of CVD grown graphene
- Methods: Optical microscopy, Raman and TEM
- Properties covered: % coverage, number of layers (thickness), level of disorder, layer stacking
- Measurement protocols, sample preparation routines and data analysis given.
- Currently out for ballot to see whether it should become a provisional work item
- Your support and input are welcome!