Group IV: Top-down assembled structures and devices

- 2 Toolmakers: Tom Cellucci (Zyvex), Peter Hauser (Nanodynamics)
- 2 End-users: Will Tong (hp), Ray Tsui (Motorola)
- 3 Gov’t agency: Nicholas Dragalakis (NIST), James Johnstone (Dept. of Trade & Ind, UK), Treye Thomas (CPSC)
- 2 Academia: Kristen Kulinowski (Rice), Daniel Woodie (Cornell)
- ANSI: 1

- Other stakeholders missing:
  - Patent office
  - Public advocacy group
  - Customers (Groups and companies)
  - Trade organizations (e.g., SEMATECH, SELETE, IMEC)
  - Labor (technicians)
  - Microfluidics and biodevice developers
  - Biotech companies
Top 5 issues for top-down structures/devices nomenclature

1. The relative importance of size vs. properties in the definition of “nano” as a prefix is not clear.
2. There is a need for a simple way of naming nanomaterials/nanostructures (of relevance to the device community)
3. The terms “top-down” and “bottom-up” are not well-defined
4. There is a need to clarify what is meant by the term “manipulation”.
5. There is a need to define the terms macro, meso, micro, nano

(Issues 1, 2, 5 are cross-cutting issues)
The relative importance of size vs. properties in the definition of “nano” as a prefix is not clear.

- The word “nano” has been usurped for funding and marketing purposes, e.g. NanoCare fabrics, nano device companies.

- We should extend the NNI definition of nanotechnology to the prefix “nano.”
  - Size: 1-100nm
  - New properties are revealed and exploited
  - Can be controlled
  - Can be integrated
There is a need for a simple way of naming nanomaterials/nanostructures (of relevance to the device community)

- We can use a numbering system with reference tables e.g., $X_1$, $X_2$, $X_3$… Can CAS system be adapted for devices?

- Need clarity in the role of shape and topography in setting terminology
The terms “*top-down*” and “*bottom-up*” are not well-defined

- “Top-down manufacturing,” “top-down assembly.”
- No agreement on the exact definition.
  - Top down: Patterning, Big-to-small…
  - Bottom up: Nature, no patterning, small-to-big…
- Is it determined by length scale or process of fabrication or structure?
There is a need to clarify what is meant by the term “manipulation”.

- Is it moving, pushing, etching, gripping/releasing, etc?

- What specifically is “nano-manipulation”?
  - How much or how little material does a tool have to move to call it a “nanomanipulator.”
There is a need to define the terms macro, *meso*, micro, *nano*

- **Meso** means “in between” in Greek, but “in between” what???
- **Different disciplines define these in different ways**
  - $1 \text{ um} > \text{ mesoporous} > 100 \text{ nm}$
  - Mesoscale devices are between micro and macro
What is the meaning of the prefix “nano-”? 
Other issues

- The use of nm or angstroms as a standard unit
- The meanings of “molecular device”, “single-molecule detection” are not standard
  - For molecular device, how many molecules are meant when using the term?
  - Set standard for single molecule detection to include a timeframe and a volume or concentration of detection.
- The terms “system”, “device” and “structure” are used differently by different disciplines. Does the device community need to agree what these mean, especially for nano devices?
- There is a need for standards of nomenclature for surface chemical analysis and other characterization techniques.
- Definitions of static performance vs. dynamic performance are not standard
Other standards work

1. Domestic: SIA (?), IEEE
Are there other areas in nanotechnology that would benefit from standardization?

1. Nanomanufacturing
2. Modeling and simulation
3. Standard methods of synthesis
4. Environmental health
5. Safety