Group IV: Top-down assembled structures and devices

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- 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 um > mesoporous > 100 nm
  - Mesoscale devices are between micro and macro

Highest priority

- 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
2. International: SEMI, International Electrotechnical Commission, ISO

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