

Toward a Proposed Ontology for Nanoscience

Michiko Tanaka
Brookhaven National Laboratory

Outline

- Introduction
 - About Nanoscale Research
- Methodology
 - Problems
 - Research Questions
 - Data Collection
 - Content Analysis
 - Meta-level Ontology
- Conclusions, limitations, recommendations
- References

Characteristics of Nanoscale Research

- Inter- and multi-disciplinary
 - Physics, Chemistry, materials science, biomedical, engineering.
 - Need to foster teamwork
- Not a new field
- A worldwide scientific competition is already underway

What is a nanometer

- A nanometer is one billionth of a meter (10^{-9})
- Four times the diameter of an individual atom
- Comparison
 - Smallest IC 250 nanometers
 - Proteins 1 to 20 nanometers
 - A human hair 100 nanometers

The benefits of nanotechnology

- Automobile & aeronautic industries
 - Nanoparticle-reinforced materials for bodies and tires
- Electronics and communications
 - Flat panel displays, wireless, data storage capacity & processing
- Chemical & materials
 - Combustion efficiency of motor vehicles
- Pharmaceuticals, healthcare, and life science
 - New nanostructured drugs, gene and drug delivery systems
- Energy technologies
 - New types of batteries, artificial photosynthesis for clean energy
- Environment
 - Reduces sources for pollutions, increased opportunities for recycling

Methodology - Problems

- There are no readily available databases or detailed classification schemes for nanoscience
- There is no specific classification code for nanoscience in INSPEC; therefore, retrieving nanoscience literature depends only on keyword searching

Methodology-Research Questions

- (1) What terms represent nanoscale research in INSPEC?
- (2) What are the components of a meta-level ontology for nanoscale research?

Methodology - Research Design

- The standard classifications
 - LCC
 - DDC
 - BC2
- Databases
 - ISI Science Citation Indexes
 - Chemical Abstracts
 - PubMed (MeSH)
 - INSPEC

Comparisoin of LCC, DDC, and BC2

	Nanoscience	Nanotechnology
LCC	Physics - Nanostructure QC176.8.N35	Nanotechnology T174.7 Nanostructure materials TA418.9.N35 Nanowire TK7874.85
DDC	Physics and mathematics - State of matter 530.4	Engineering and allied operations -Nanotechnology 620.5
BC2	AY68 Nanotechniques in Science B68 Nanoscience in Physics C68 Nanoscience in Chemistry D68 Nanoscience in Earth Science	U68 Nanoscience technology U68 AY2 Nanoscience U68 CC Analytical chemistry U68 U... Nanotechnology

Methodology – Data collection INSPEC

- Selection of nanoscience papers
 - Limited to articles from the journals with the nano-prefix in titles
 - Limited to 2003 publications
- ↓
- Eight journals, 690 papers
- ↓
- Content analysis

Methodology – Data collection process INSPEC

Subject	Headings	Frequencies
Physics Condensed Matter	Structure of solid clusters, nanoparticles, and nanostructured materials	160
Materials Science	Other methods of preparation of materials	95
Engineering Semiconductor	Annealing processes in semiconductor technology	95
Physics Condensed Matter	Structure of fullerenes and fullerene-related materials	71
Engineering Electron devices	Molecular electronics	51
Physics Condensed Matter	Low-dimensional structures	47

Methodology – Data collection Controlled vocabulary

<u>Controlled index terms</u>	<u>Frequencies</u>
• Nanoparticles	129
• Nanostructured Materials	111
• Nanotechnology	88
• Transmission Electron Microscopy	85
• Self-Assembly	81
• Iii-V Semiconductors	64
• Materials Preparation	64
• Organic Compounds	64
• Carbon Nanotubes	57
• X-Ray Diffraction	52
• Particle Size	50
• Scanning Electron Microscopes	49
• Gold	47
• Nanowires	47
• Molecular Biophysics	47
• Nanoelectronics	41

Methodology – Content Analysis

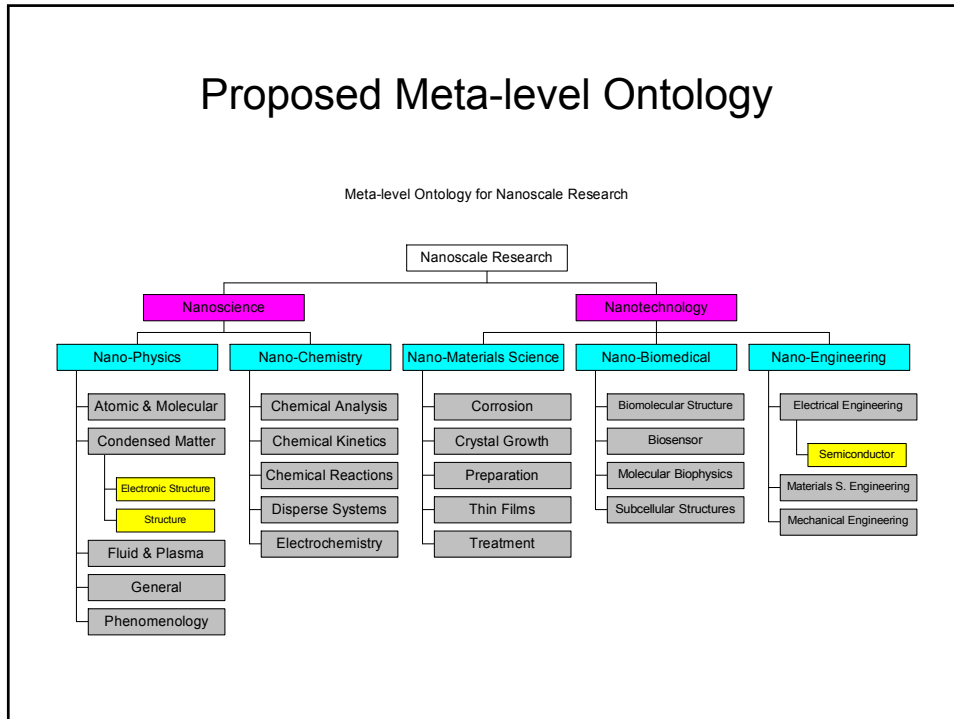
- Confirmed 4 major subjects in controlled vocabulary
 - Physics, Chemistry, Materials Science, Biomedical
 - 18 termsall in 4 subjects
 - 72 terms.....in Physics, Chemistry, Materials S.
 - 3 terms.....in Physics, Chemistry, Biomedical
 - 1 termin Physics, Materials S. Biomedical
 - 51 terms.....in Chemistry, Materials S.
- ↓
- Physics 27 Unique controlled terms
 - Chemistry 96 Unique controlled terms
 - Materials S 83 Unique controlled terms
 - Biomedical 38 Unique controlled terms

Generating an Ontology

- Purpose of the ontology
 - Organize nanoscale research knowledge and make it accessible to interdisciplinary nanoscale research population
- 3 ways to generate an ontology
 - Bottom-up
 - Top-down
 - Middle-out
- Process of building an ontology
 - Identify the purpose & scope of ontology
 - A three-step process
 - Capture & coding
 - Integrating existing ontologies
 - Evaluation & documentation

(Uschold and Gruninger, 1996)

Proposed Meta-level Ontology



Conclusions, limitations, recommendations

- **Conclusions**

- **Ontology**

- Standardization of information
- Expandable information
- Solution for the problem of interdisciplinary research

- **Limitations**

- Limited data

- **Recommendations**

- Data collection from the classical disciplinary journals
- Include uncontrolled index terms