



Nanotechnology: Real world applications today, but a bumpy road to revolution ahead

Patti Glaza
VP/Publisher

Small Times

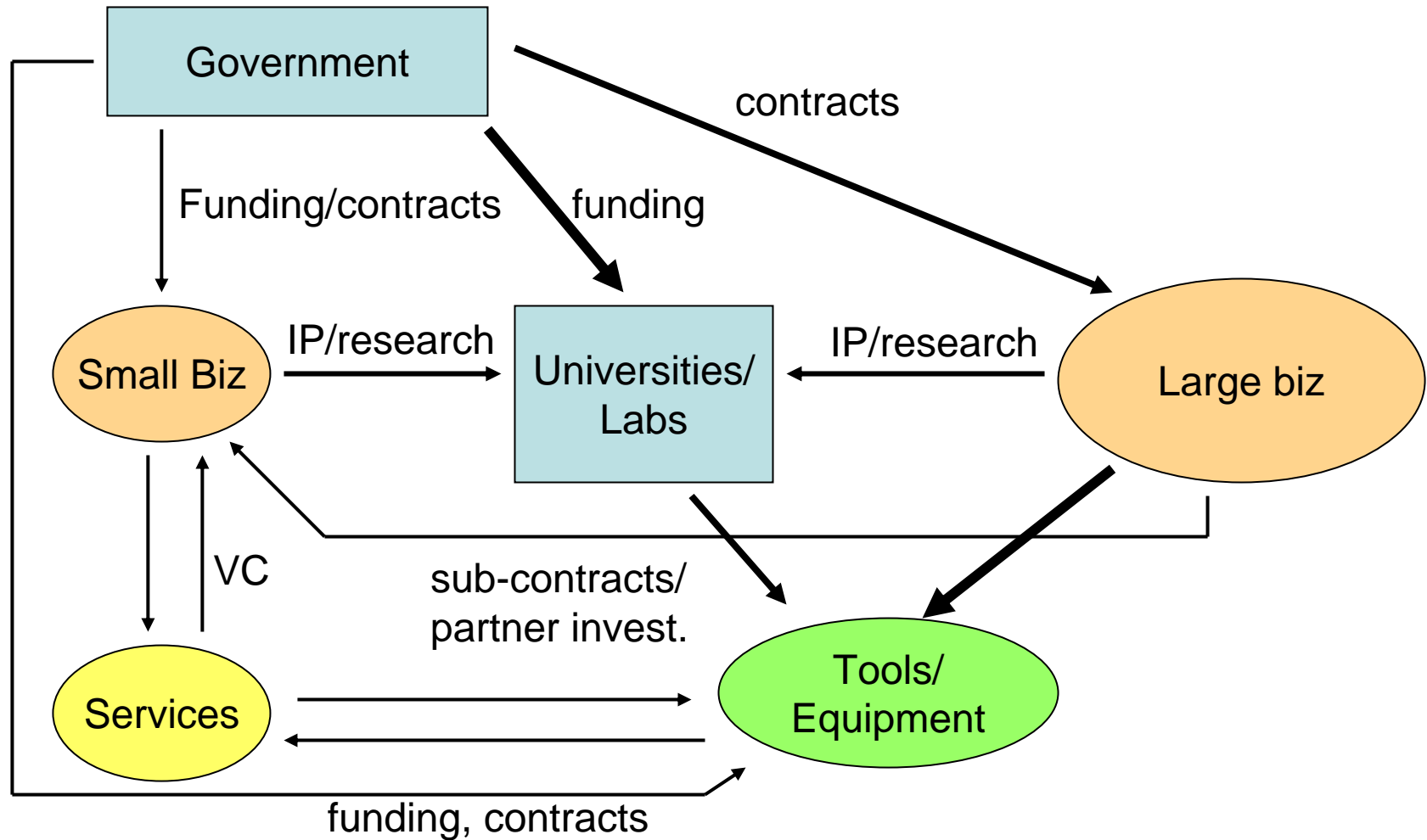
- Driving the commercialization of micro and nanotechnologies since 2001
- Small Times Magazine
 - 27,000 qualified subscribers
 - Global circulation
- SmallTimes.com
 - Daily & breaking news
- Small Times Direct e-newsletter
- Small Times NanoCon International
 - 2007: Nov. 14-16 Santa Clara, CA



Bringing nanotechnologies to market

- Nanotechnology ecosystem
- Funding trends
- Industries bringing nano to market
- Nano – is it safe?

Nanotechnology ecosystem



Bringing nanotechnologies to market

Regional clusters supported by:

- Existing industry base - customers
- Strong universities
- Funding
- Entrepreneurial support/climate
- Community





University Nano Investment

2006 Survey Results



PEER NANO RESEARCH

FACILITIES

1	
2	
3	
4	1 University at Albany-SUNY
5	2 Cornell University
6	3 Ohio State University
7	4 University of North Carolina
8	5 Northwestern University
9	6 Arizona State University
10	7 University of Michigan
	8 Rice University
	9 University of Illinois at Urbana-Champaign
	10 Purdue University

PEER NANO COMMERCIALIZATION

INDUSTRIAL OUTREACH

1	
2	
3	1 University at Albany-SUNY
4	2 University of Minnesota
5	3 Purdue University
6	4 University of North Carolina
7	5 Rutgers University
8	6 University of Central Florida
9	7 University of Michigan
10	8 North Carolina State University
	9 Northwestern University
	10 Cornell University

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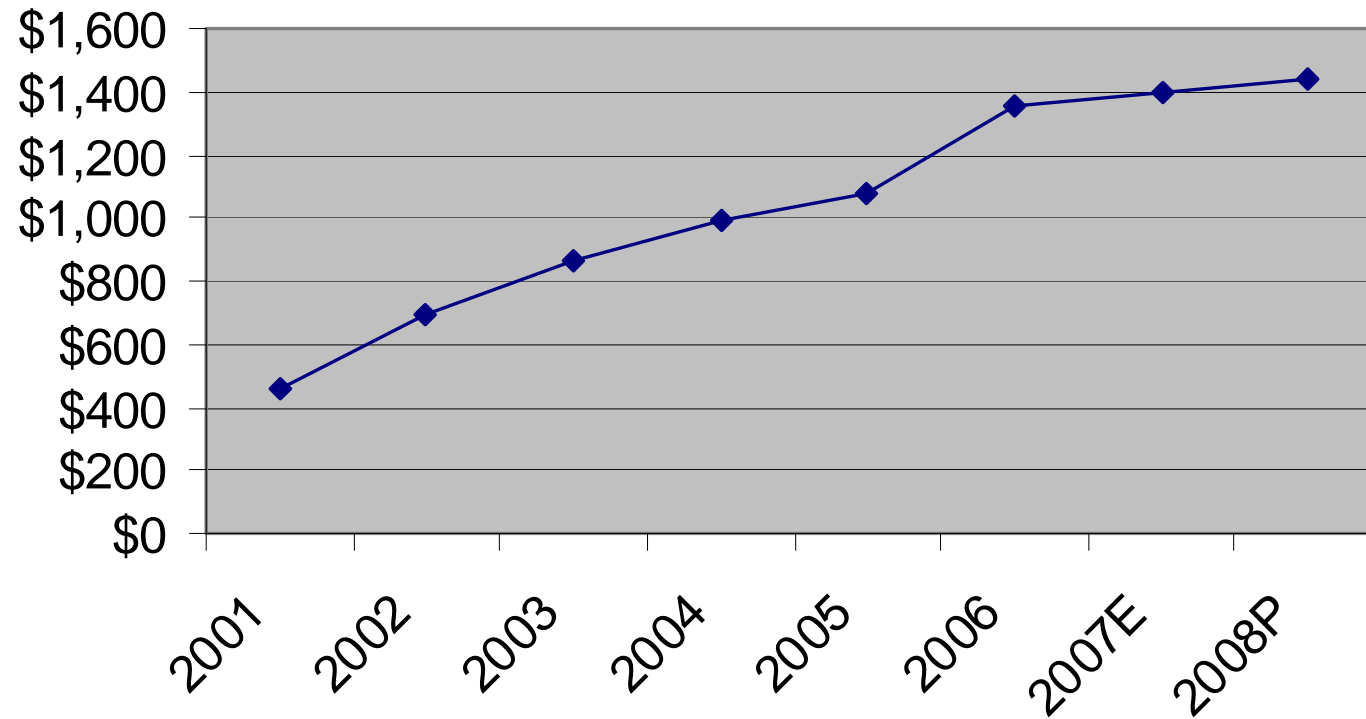
US Federal Funding – NNI Budget

NNI Budget, 2006-2008 (dollars in millions)			
	2006 Actual	2007 Estimate*	2008 Proposed
NSF	359.7	373.1	389.9
DOD	423.9	417.2**	374.7
DOE	231.0	293.3	331.5
DHHS (NIH)	191.6	170.2	202.9
DOC (NIST)	77.9	89.3	96.6
NASA	50.0	25.0	24.0
EPA	4.5	8.6	10.2
USDA (CSREES)	3.9	3.9	3.0
DHHS (NIOSH)	3.8	4.6	4.6
USDA/FS	2.3	2.6	4.6
DHS	1.5	2.0	1.0
DOJ	0.3	1.4	0.9
DOT (FHWA)	0.9	0.9	0.9
TOTAL	1,351.2	1,392.1	1,444.8

http://www.nano.gov/NNI_FY08_budget_summary-highlights.pdf

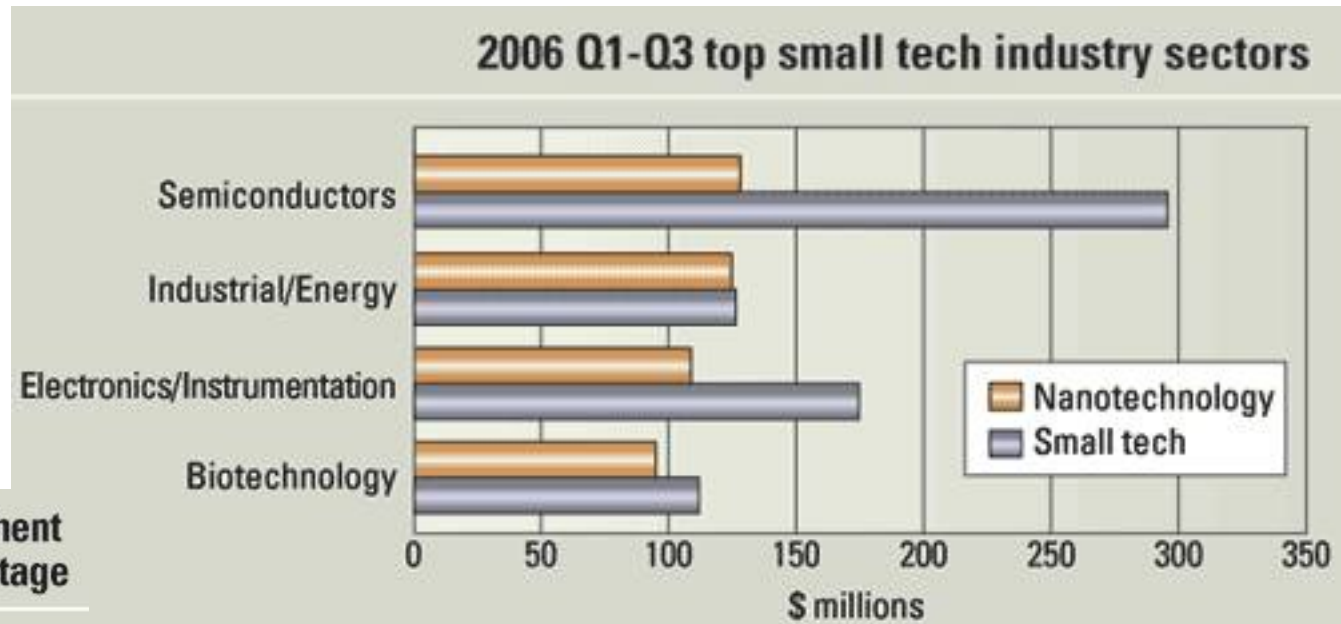
US Federal Funding – NNI Budget

NNI Budget 2001-2008P

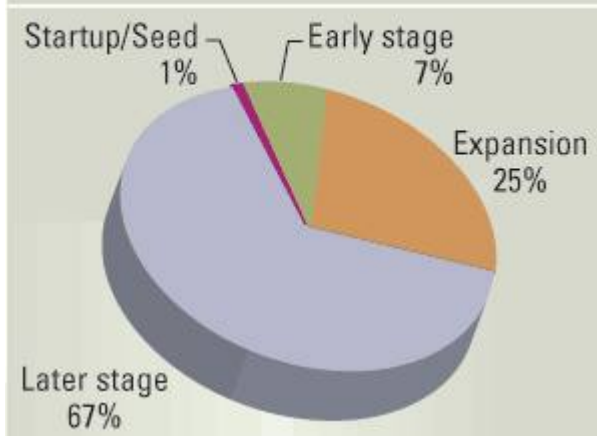


<http://www.nano.gov/html/about/funding.html>

US Venture Capital Funding



2006 Q1-Q3 small tech investment by stage



- 2006 venture capital numbers strong
- ...but where is the pipeline for 2012?

Small Times Magazine, January 2007

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Technology enablers - Tools/Metrology

- “Seeing” and measuring at the nanoscale
- Standards and approved methods critical for commercialization
- Costs of atomic scale imaging decreasing rapidly
 - More research
 - More sophisticated workforce
 - More innovation
- Industry consolidation
 - Imago/Oxford nanoScience
 - Agilent/Molecular Imaging
 - KLA/ADE
 - Nanometrics/Accent Optical

Key Industry Segments

- Energy
- Bio/life sciences
- Computers/electronics
- Defense/aerospace/automotive
- Consumer products

Energy

➤ Light, Power, & Efficiency

- Batteries – size, performance
- Catalytic converters (improved performance & emission levels)
- Fuel enhancers
- Lighting

➤ Killer apps –

- Solar
- Hydrogen economy
- Energy transmission



Photo Courtesy: Plug Power

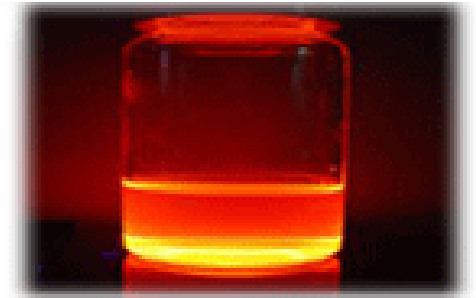


Photo Courtesy: LEDtronics

Energy – Solar company examples

➤ Innovalight, Inc

- Printed, flexible solar cells
- Solvent-based silicon nanomaterials
- Recent \$7.5 million series B



Silicon Ink

Photo Courtesy: Innovalight, Inc.

➤ NanoSolar

- Printed, flexible solar cells: CIGS
- \$100 million late-stage
- Building own fab

Medical – Today's applications

➤ Wound Care

- Silver-based nanocoating for an antimicrobial effect

➤ Bone restoration

➤ Surgical tool coatings

➤ Drug discovery

➤ Catheters / stents

➤ Filtration

- Virus sortation
- Masks & breathing equipment
- Air filters

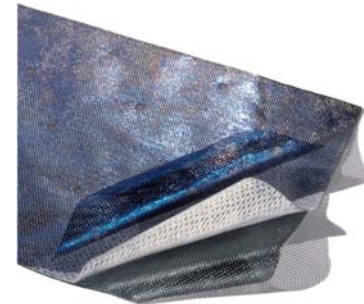


Photo Courtesy: smith&nephew/Nucrust



Photo Courtesy: Acrymed

Medical – Today's applications

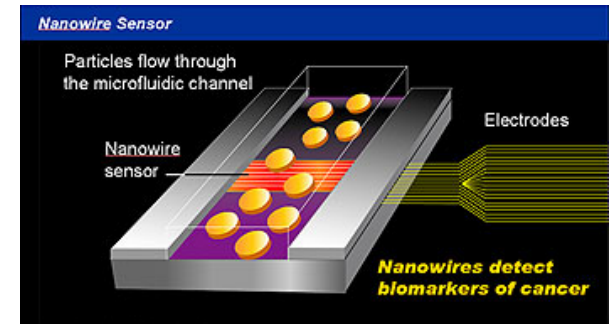
FDA approved therapeutics

- Gadolinium chelate for MRI imaging (Gd-DTPA Dimeglumine)
- Iron oxide particles for MRI imaging (Feridex)
- Products using NanoCrystal technology (Rapamune, Emend)
- Liposomes (Doxil, DaunoXome)
- Microemulsions (Cyclosporine)
- Albumin-bound nanoparticles (Abraxane)

Nakissa Sadrieh, Ph.D., Office of Pharmaceutical Science, CDER, FDA

Medicine & Health - tomorrow

- Advanced diagnostics
- Targeted drug delivery
- Implants



Reference: Jim Heath, California Institute of Technology

Nanosphere - nucleic acid & protein detection – ultra sensitive

Magforce - Cancer therapies

Nanospectra Biosciences, Inc. – cancer therapies

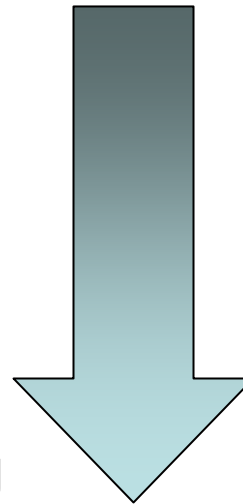


Photo Courtesy: Nanosphere

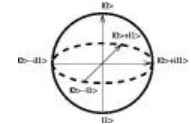
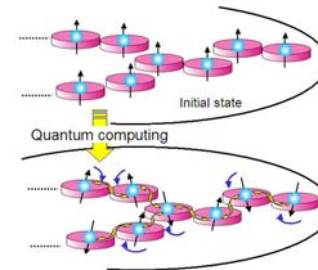
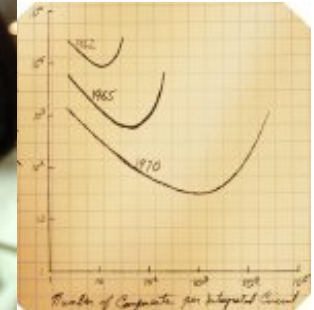
Computing/Electronics

- Memory
 - Displays – OLEDs, CNT, quantum dots
 - Storage
 - Molecular circuitry
 - Quantum computing
-
- Semiconductor manufacturing – 65nm to 45nm to 32nm to 22nm

Near-term



Long-term



Computing – Company examples

➤ Nantero

- Nanotube-based/non-volatile Random Access Memory (NRAM)
- Disruptive – replacement for DRAM, SRAM & flash memories

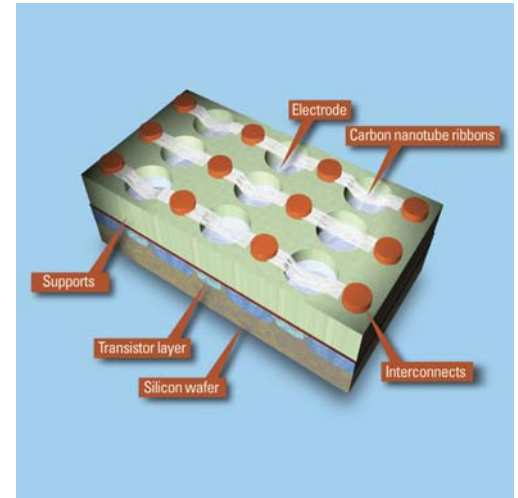


Photo Courtesy: Nantero

➤ Luxtera

- \$14 million later-stage
- Optical transceivers fab'ed on single silicon chip
- Enabling cost-viable replacement of copper wiring

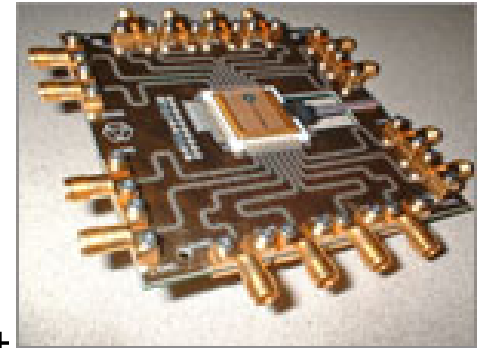


Photo Courtesy: Luxtera

Military/Defense/Transportation

- Power: portable/long-life
- Fuel cells
- Protective gear
- Coatings
- Composites
- Communications
- Sensors/detection
 - Explosives
 - Biological agents

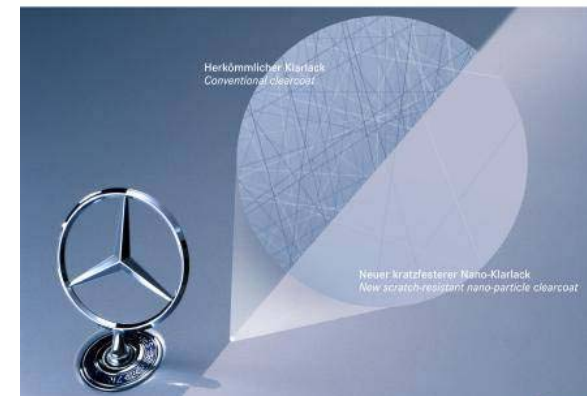


Photo Courtesy: DaimlerChrysler

Consumer Products

- Sporting goods
- Paints/coatings
- Clothing
- Appliances
- Cosmetics
- Supplements
- Food



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Risky Business – is nano safe?

- Who cares about the debate?
- Why care about the debate?
- Fringe voices with impact
- Putting risk in context
- Is the risk being ignored?
- High stakes game

Who cares about the debate?

- Researchers
- Companies developing or incorporating nanotechnologies
- Government agencies (development & regulation)
- Environmental & Social special interest groups
- Publicly appointed officials?
- Public?

Why care about the debate?

Stake holder's perspectives:

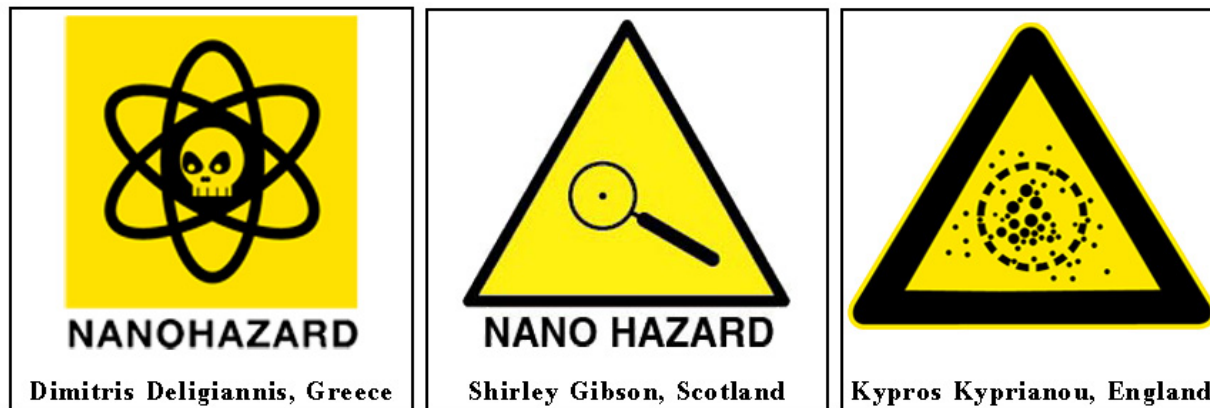
- Researchers – **funding**
- Companies developing or incorporating nanotechnologies – **revenue**
- Government agencies (development & regulation) – **funding**
- Environmental & Social special interest groups - **funding**
- Publicly appointed officials? – **election**
- Public – **potential to improve or jeopardize lives**

Fringe voices are good at PR

There is a critical need to evaluate the social implications of all nanotechnologies; in the meantime, the ETC group believes that a moratorium should be placed on research involving molecular self-assembly and self-replication.

(ETC website www.etcgroup.org)

- Call for research moratorium and nano hazard labeling



Fringe voices are good at PR

To The Hon Ian Macfarlane MP
Minister for Industry, Tourism and Resources

[...] Nanotechnology raises serious social, political and ethical questions, as well as introducing significant new risks to human health and the environment. However, to date nanotechnology's commercialisation has been driven by business interests.

There has been no effort to involve the community in decision making about nanotechnology, or to introduce new laws to protect workers, the public, and the environment from its risks. [...]

I am writing to request that you support a moratorium on the commercial research, development and release of nanotechnological materials and products ...

Friends of the Earth – Form letter

- Call for moratorium on commercial research, development and commercialization of nanotechnology

Fringe voices are good at PR

“Greens urge ban on nanomaterials in toiletries”

— *March 17, 2007, Australian Broadcasting Corporation, Online*

The New South Wales Greens say the use of nanomaterials in some sunscreens and shampoos could become the asbestos problem of the 21st century.

- Call for ban on sale of cosmetics/toiletries containing nanomaterials

Perspective

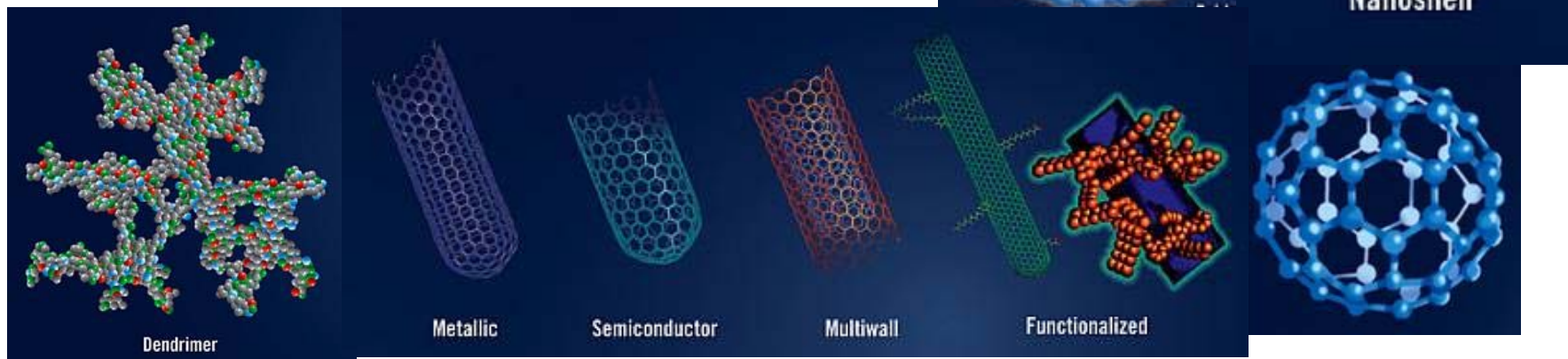
- Does nano = asbestos?
- Is nano uncharted territory?
- Public 'good' verses public 'bad'
- Are the risks really being ignored?

Is this the right debate?

Does nano = asbestos?

“Is nanotechnology safe?” the right debate?

- No.
- Nanotechnologies
- Some are, some aren't



Uncharted Territory?

Humans have been developing new engineered products since the beginning of time...and many have associated public risks:

- automobiles
- plastics
- lighting
- pesticides
- vaccinations/medications

It's not about STOPPING innovation...must work to minimize risk of public 'bad' and max public 'good'

More perspective...

- Silver nano ions verses chemical laden laundry detergents?
- Carbon nanotubes in longer-lasting batteries or landfills full of shorter lasting, toxic batteries
- Name that ingredient...what is really in those cosmetics we are wearing?
- Reduction of CO2 emissions or continued dependence on decreasing reserves of oil, gas, and coal?

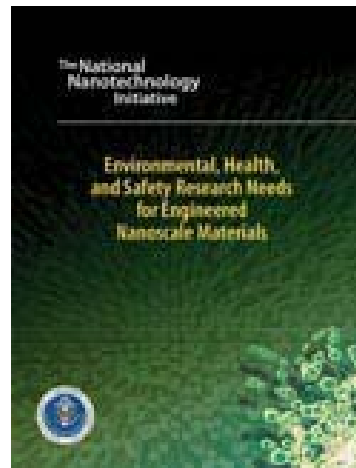
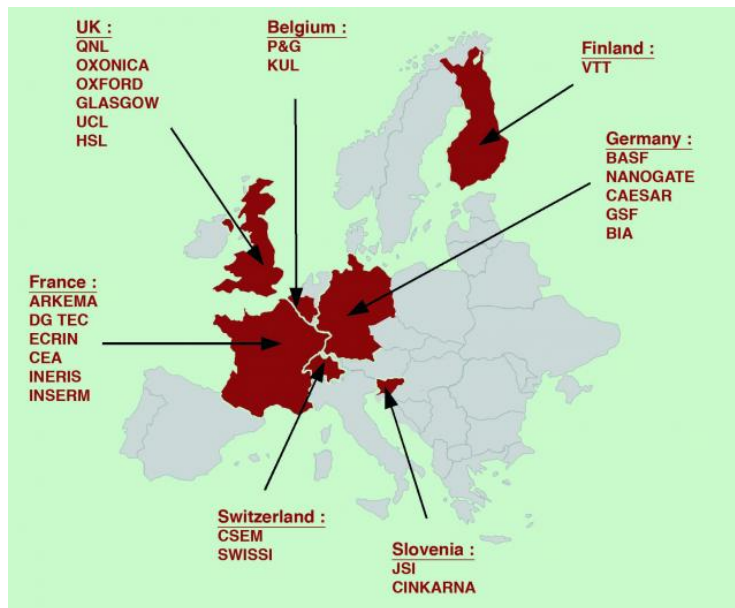
Are the risks being ignored?

No.

- Classifications of risks
 - Workplace safety
 - Consumption
 - Environmental
- Industry, government, academia collaborating worldwide
- Identify risk priorities, develop standards and determine best practices

Are the risks being ignored?

- EPA, FDA, NIOSH, CDC all have initiatives
- Nanosafe collaboration in Europe
- DuPont/Environmental Defense framework



Are the risks being ignored?

ICON survey on nanotechnology workplace practices determined:

- Organizations are seeking toxicology information and best practice information – need more information/guidelines
- Companies are implementing EHS programs and training:
 - Larger companies – cleanrooms, separate HVAC systems, closed piping
 - Smaller companies – disposable PPE: i.e dust masks, body coverings, respirators, etc.

International Council on Nanotechnology
Icon.rice.edu - Rice University

The stakes are high!

- R&D funding
- R&D advances
- Technology leadership
- Commercial growth
- Human lives...



Top 10 nanotechnologies

...for the developing world

1. Energy storage, production and conversion
2. Agricultural productivity enhancement
3. Water treatment and remediation
4. Disease diagnosis and screening
5. Drug delivery systems
6. Food processing and storage
7. Air pollution remediation
8. Construction
9. Health monitoring
10. Vector and pest detection and control



PLoS Med 2006; 2(5): e97

Peter A. Singer

McLaughlin-Rotman Centre for Global Health, University of Toronto



Top nanotechnologies

...for the developed world

- 1. Energy storage, production and conversion**
- 2. Water treatment and remediation**
- 3. Disease diagnosis and screening**
- 4. Drug delivery systems**
- 5. Food processing and storage**
- 6. Air pollution remediation**
- 7. Construction**
- 8. Health monitoring**



Action is critical

Industry needs to take an active role in the debate

- Frame the issue – PR offensive
- Take active role with applicable federal agencies
- Workplace safety should be top priority

Ignoring the problem won't make it go away...