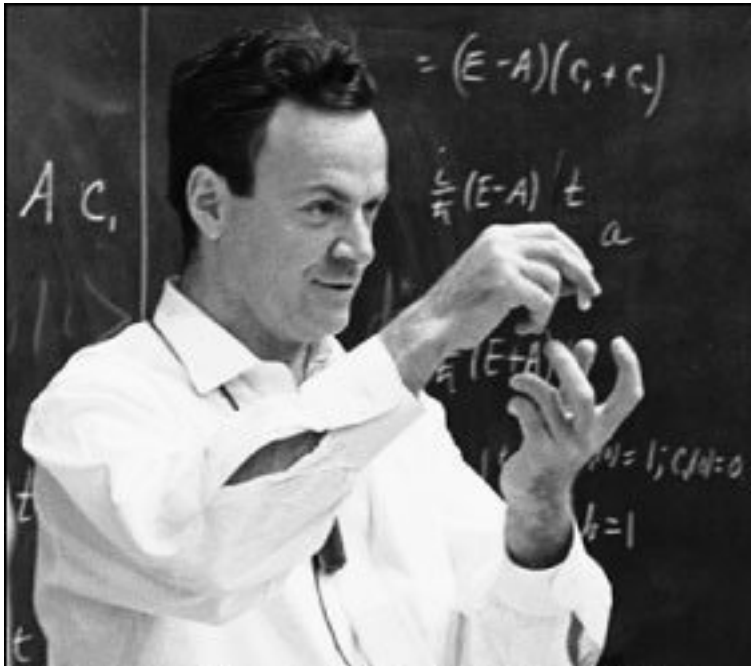


luxresearch

Nanotechnology's Impact on Consumer Products



Michael Holman, Senior Analyst
Presented at EU
Thursday, October 25, 2007



“There’s plenty of room at the bottom.”

-Richard Feynman, December 29, 1959



“Plenty of room at **this** bottom”

-Topless Humans Organized for Natural Genetics (THONG), October 6, 2004

Agenda

- Overview of nanotech commercialization
- Nanotech's impact on selected products
- Environmental, health, and safety issues

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What's nanotechnology?

Not “nano by accident”:

- Ancient Egyptian pottery
- Stained glass
- Cat litter

“The *purposeful engineering* of matter at *scales of less than 100 nanometers (nm)* to achieve *size-dependent* properties and functions.”

Really small

Not just “small;” “small and different”

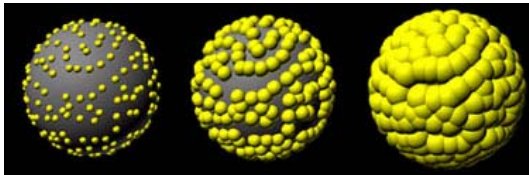
Products built with nanotechnology exploit *size-dependent properties* to do amazing things



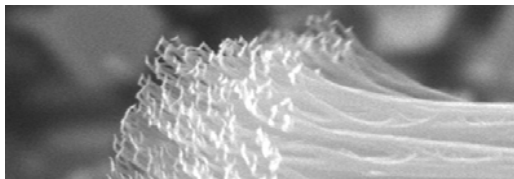
Carbon nanotube crossbar memory
(LSI Logic, BAE Systems licensing from Nantero)
Van der Waals forces hold nanotube crossbars together



Semiconductor nanocrystal biolabels
(Invitrogen though Quantum Dot Corp acquisition)
Diameter of particle determines color of light emitted



Gold nanoshell cancer treatment
(Nanospectra Biosciences)
Size and curvature of shell determines light absorption



Artificial setae
(U.S. Army contracting with Nanosys to develop)
Weak atomic interactions allow soldiers to climb walls

Conventional wisdom about nanotechnology is wrong

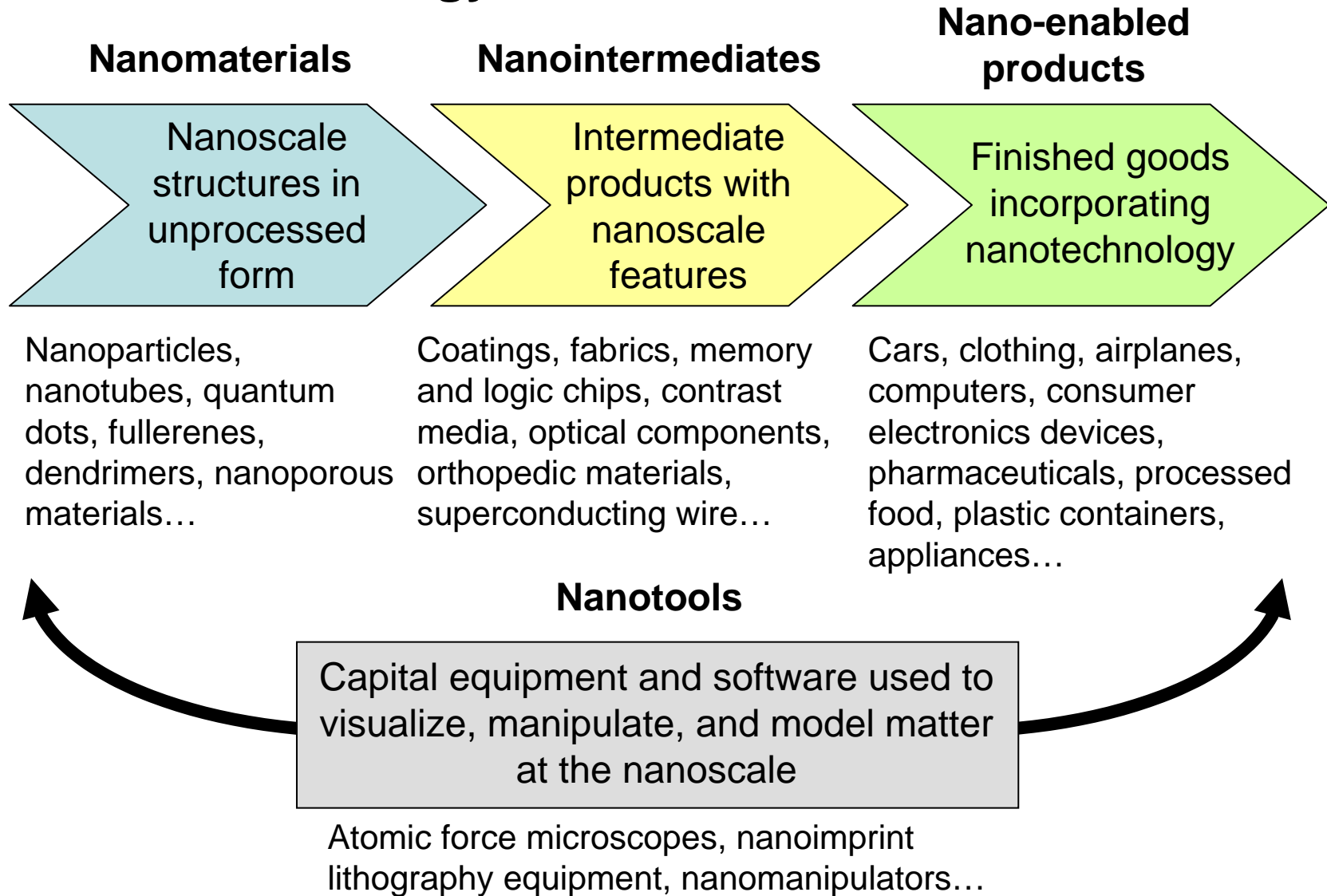
Conventional wisdom

A “nanotechnology market” is emerging, comprised of “nanotechnology companies” selling “nanotechnology products”

Commercial reality

There is no “nanotechnology market;” there *is* a nanotechnology value chain

The nanotechnology value chain



Conventional wisdom about nanotechnology is wrong

Conventional wisdom

A “nanotechnology market” is emerging, comprised of “nanotechnology companies” selling “nanotechnology products”

All “nanotechnology products” are new

Commercial reality

There is no “nanotechnology market;” there *is* a nanotechnology value chain

Not all nanotechnology is new. *Emerging* nanotechnology is developing against a backdrop of *established* nanotechnology

Conventional wisdom about nanotechnology is wrong

Conventional wisdom

A “nanotechnology market” is emerging, comprised of “nanotechnology companies” selling “nanotechnology products”

All “nanotechnology products” are new

Anything “nano” has the potential for huge profit margins

Commercial reality

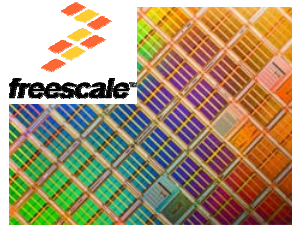
There is no “nanotechnology market;” there *is* a nanotechnology value chain

Not all nanotechnology is new. *Emerging* nanotechnology is developing against a backdrop of *established* nanotechnology

Many products incorporating nanotechnology will be only marginally profitable

Early nano-enabled products are on the market now

Freescale
magnetoresistive
memory (MRAM)



Wilson Double
Core tennis balls



Eddie Bauer
Ruston Fit Nano-
Care khakis



3M Adper Single
Bond Plus
dental adhesive



Wyeth Rapamune
immuno-suppressant



Smith & Nephew Acticoat 7
antimicrobial wound dressing



Laufen Gallery washbasin
with Wondergliss



Petrol Ofisi
with diesel
fuel catalysts

Henkel Nanit-
Activ toothpaste
for sensitive teeth



Behr NanoGuard
Mildew-resistant paint



Hummer H2

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Case study: near-term nanotech innovations in a phone

Nanostructured electrodes

(Batteries from A123 Systems, supercapacitors from Cap-XX, fuel cells from many)

OLED or LEP display

(Universal Display, Cambridge Display Technologies)

Antimicrobial coating

(Nanux, Bio-Gate, NanoHorizons, others)



Nano-enabled multipurpose memory

(Altis, Freescale, Nantero, Zettacore)

Nanopatterned logic chip

(Molecular Imprints, EV Group, SUSS MicroTec)

Nanostructured chip cooling system

(CoolChips, Thorrn Micro Technologies, Nanoconduction)

Source: March 2005 Lux Research report "How Nanotechnology Adds Value to Products"

Case study: nanotech innovations in a juice bottle

Nutraceutical carriers
(Aquanova with BASF/Solgar, Nutralease, DuraFizz)

Food quality sensors
(pSiNutria, Nanoident, Hanson Technologies)

Gas barrier coatings
(Honeywell, nSec, NanoPack, InMat, Dow Chemical, others)

UV-blocking plastic
(Oxonica, NanoProducts, Air Products, Evonik,)

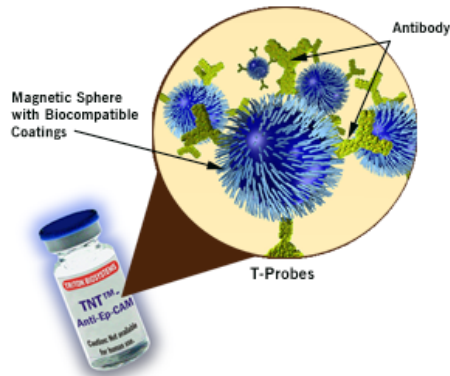
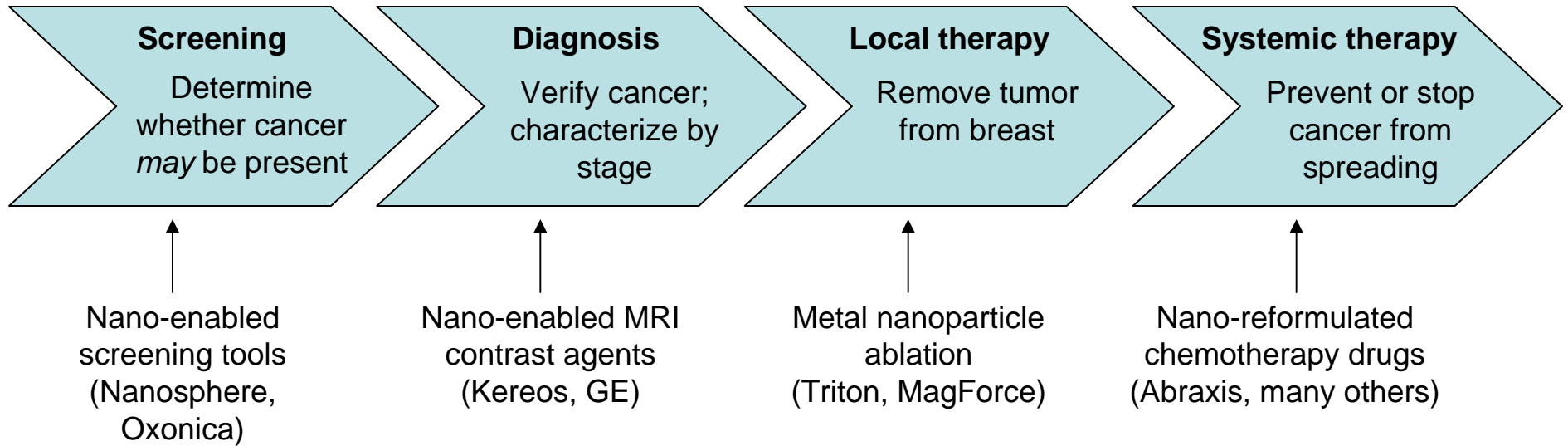
Antimicrobial coating
(Nanux, Bio-Gate, NanoHorizons, others)

Printable RFID
(NovaCentrix, NanoMas, Plextronics, Polyera)

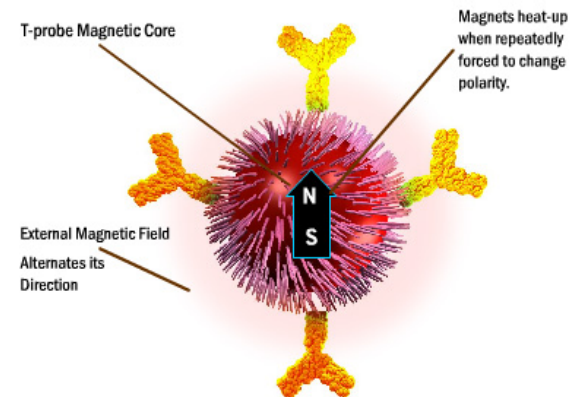


Source: Lux Research reference study, *The Nanotech Report, 5th Edition*

Case study: nanotech innovations in cancer treatment



TRITON BIOSYSTEMS
Targeted Nano-Therapeutics™ for Cancer



Source: March 2005 Lux Research report “How Nanotechnology Adds Value to Products”

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Firms need to handle three aspects of nanotech EHS...

Real risks

Nanomaterials might have negative effects on people or the environment



Rat exposed to cobalt nanoparticles on the left side, bulk cobalt on the right side

Best case: Nanomaterials prove to be more dangerous than ordinary substances in only a handful of cases

Worst case: Studies show that many nanomaterials have elevated hazard and are more difficult to control

Perceptual Risks

Nanotechnology might come to be seen as unsafe – irrespective of actual harm



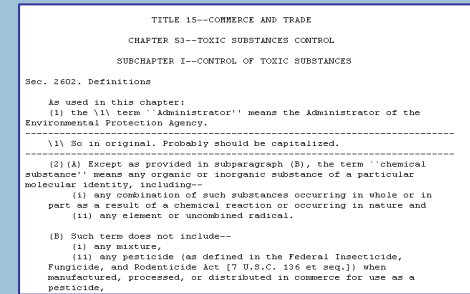
Protest of the use of Nano-Tex fabric treatment outside an Eddie Bauer store

Best case: Consumers appreciate the benefits nanomaterials can offer and embrace the technology

Worst case: Nanotech comes to be seen as synonymous with danger and consumers are reluctant to accept it

Regulations

Regulations might – rightly or wrongly – slow or block commercialization



Text of the Environmental Protection Agency's Toxic Substances Control Act

Best case: Existing regulatory frameworks can be painlessly adapted to manage nanomaterials

Worst case: Risks drive regulators to impose stringent testing requirements on all nanomaterials

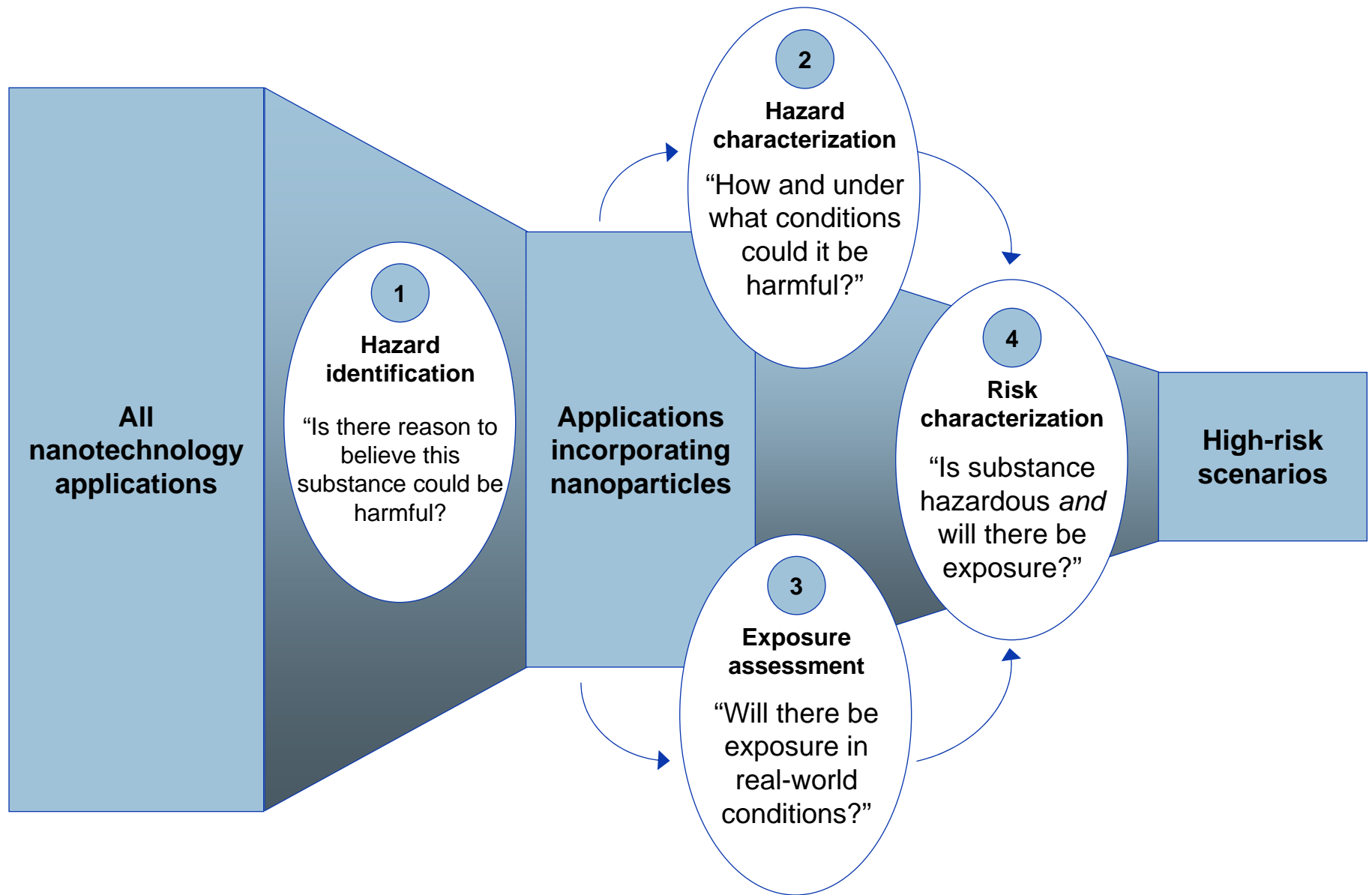
Source: May 2006 Lux Research Report "Taking Action on Nanotech Environmental, Health, and Safety Risks"

Companies struggle with all three aspects today

“We’ve stopped development where costs were too high to ensure no exposure or risk across the lifecycle, or we couldn’t clearly judge hazard potential due to the lack of accepted methods. It’s quite complicated; we can’t set decision points today.”

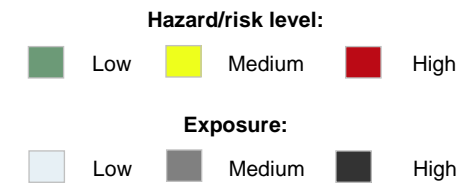
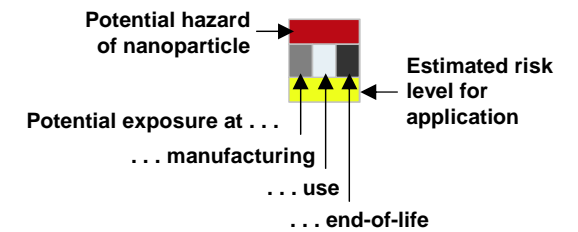
“We promote the benefits better products bring, without talking about technology. With nanotech, it’s no different: You won’t hear us talking about nanotech or advertising it in any way. That’s our strategy for dealing with potential negative publicity.”

“Our CEO decided it was too early to make any more investments in nanotech until the FDA makes some decisions on how it will be handled. We’re all very disappointed about this since we have already dedicated significant resources.”

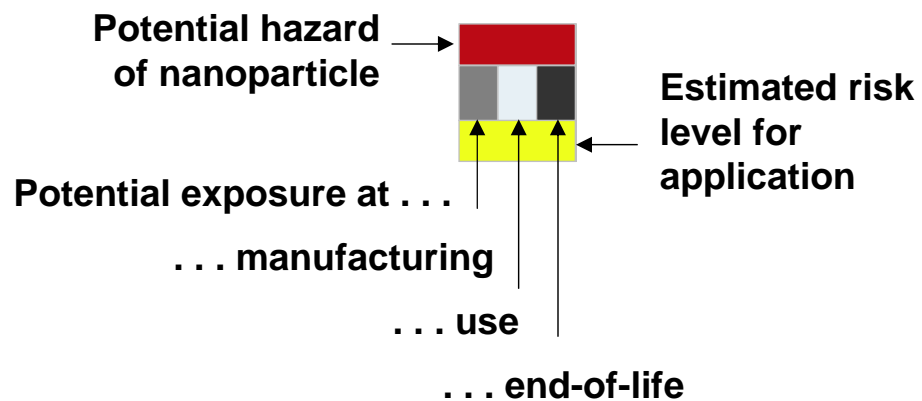


Source: Lux Research Report "A Prudent Approach to Nanotechnology Environmental, Health, and Safety Risks"

	Single-walled carbon nanotubes	Multi-walled carbon nanotubes	Nanoclay particles	Cadmium-selenide quantum dots	Zinc oxide nanoparticles	Titanium dioxide nanoparticles	Dendrimers	Fullerenes	Nanocrystalline drug formulations	Silicon nanowires
In vivo imaging	High Hazard, High Exposure			High Hazard, High Exposure			Medium Hazard, High Exposure	High Hazard, High Exposure		
Structural composite for automotive body	High Hazard, High Exposure	Medium Hazard, High Exposure	Low Hazard, High Exposure					High Hazard, High Exposure		
Sunscreen additive					Medium Hazard, High Exposure	Low Hazard, High Exposure	Medium Hazard, High Exposure	High Hazard, High Exposure		
Food additive					Medium Hazard, High Exposure	Low Hazard, High Exposure	Medium Hazard, High Exposure	High Hazard, High Exposure		
Display backplane	High Hazard, High Exposure									Low Hazard, High Exposure
Polishing agent					Medium Hazard, High Exposure	Low Hazard, High Exposure				
Memory chip	High Hazard, High Exposure			High Hazard, High Exposure				High Hazard, High Exposure		Low Hazard, High Exposure
Printer toner							Medium Hazard, High Exposure			
Drug							Medium Hazard, High Exposure	High Hazard, High Exposure	Low Hazard, High Exposure	
Flexible solar cell				High Hazard, High Exposure		Low Hazard, High Exposure		High Hazard, High Exposure		Low Hazard, High Exposure



	Nanoporous silicon	Dendrimers	Single-wall carbon nanotubes
Structural composite for auto body			
Drug			
Memory chip			



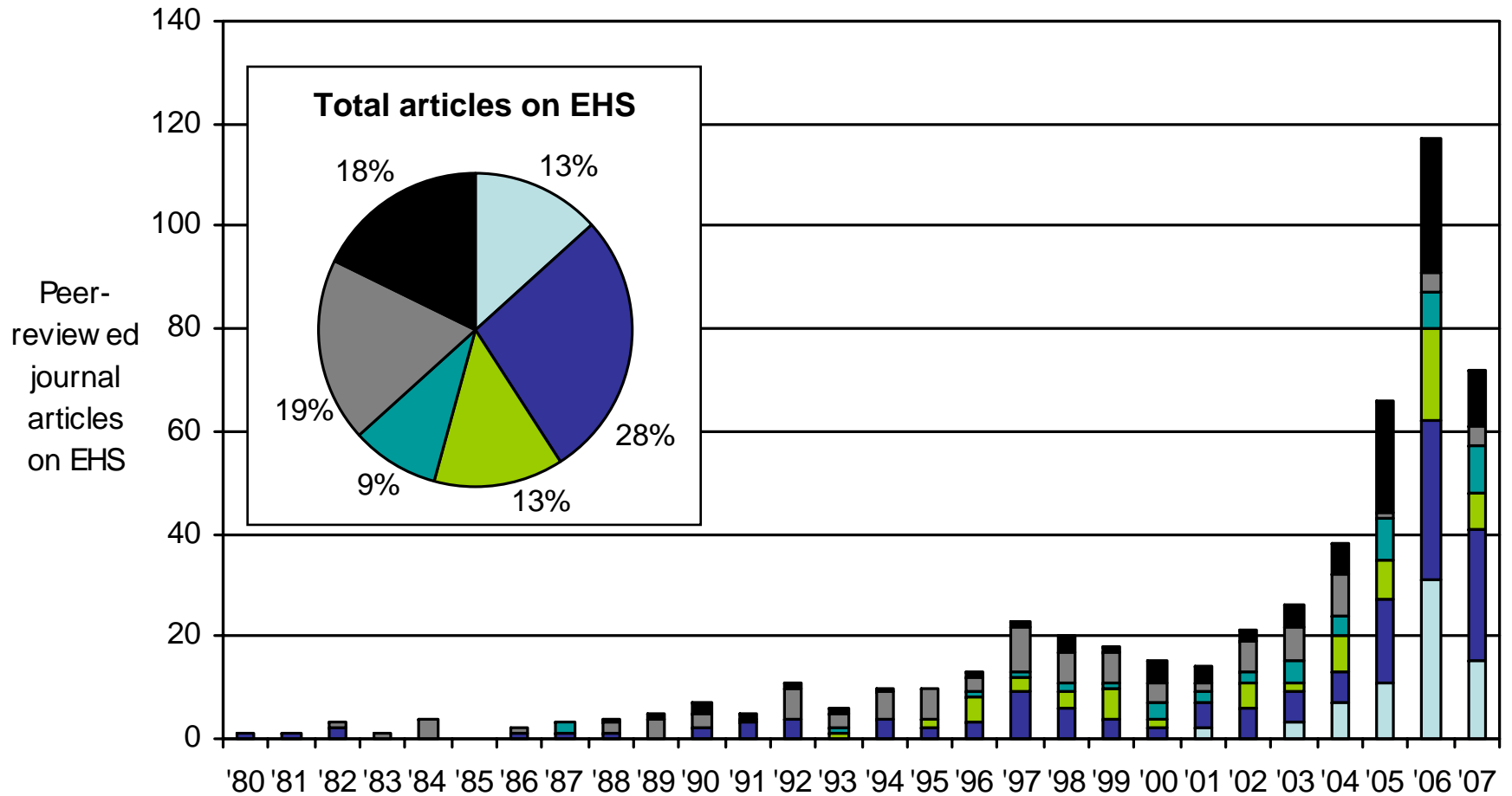
Hazard/risk level:

- High
- Medium
- Low

Exposure:

- High
- Medium
- Low

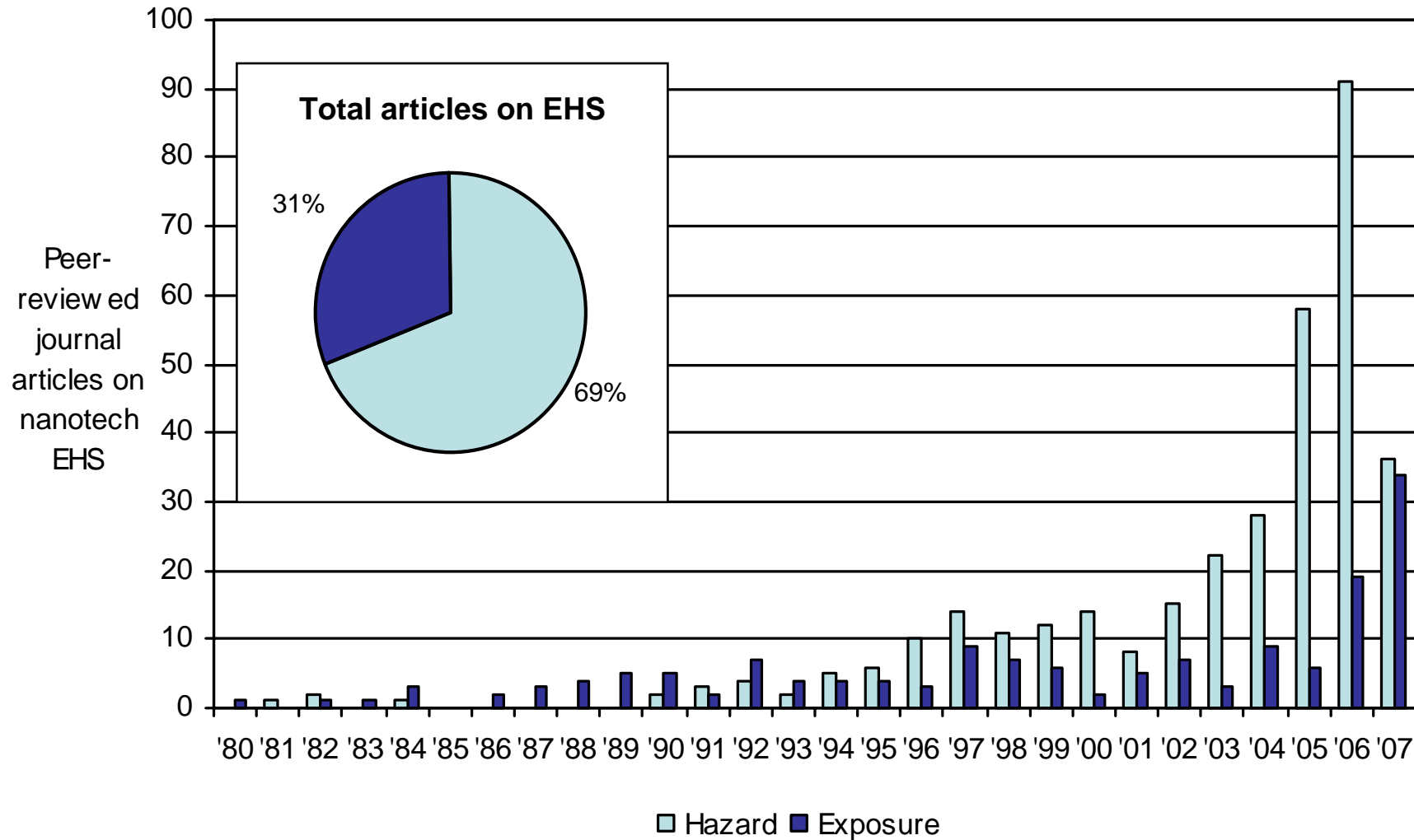
Carbon and ceramics dominate nanotech EHS research



■ Carbon nanotubes
 ■ Ceramic nanoparticles
 ■ Fullerenes
 ■ Metal nanoparticles
 ■ Molecular aggregates
 ■ Other







Sources: ICON database (icon.rice.edu), review articles, literature searches

In 2007 nanomaterial exposure studies gain ground



Sources: ICON database (icon.rice.edu), review articles, literature searches

Consumers are uninformed but optimistic

Researcher(s)	Year	Description	People	Region	Awareness	Attitude	Key finding
Currall, King, Lane, Madera, and Turner ^a	2005 2004 2005	Telephone survey; online survey; telephone survey	503; 4,452; 501	U.S.	Low		Perception of benefits influence the perception of risks – if benefits are perceived to be low, concern about risk will be greater
Peter D. Hart Research Associates, Inc. ^b	2006	Telephone survey	1,014	U.S.	Low		30% have heard something about nanotech, but 42% still unaware – most with opinions believe benefits and risks will be about equal
Kahan, Slovic, Braman, Gastil, and Cohen ^c	2006	Online survey	1,800	U.S.	Low		People with “individualistic” values focus on the benefits of nanotech, while “communitarian/egalitarian” types focus on the risks
Siegrist, Cousin, Kastenholz, and Wiek ^d	2006	Telephone survey	153	Switzerland	N/A		Participants hesitant to buy nanotechnology in foods and food packaging, depending upon perceived benefits
Market Attitude Research Services, Pty Ltd ^e	2005 2007	Telephone survey; telephone survey	1,000; 1,000	Australia	Low		54% of Australians believe potential benefits outweigh risks in 2007, as opposed to 39% in 2005
Peter D. Hart Research Associates, Inc. ^f	2007	Telephone survey	1,014	U.S.	Low		Repeat of 2006 poll finds similar results despite doubled number of nanotech consumer products

Conclusions

- Nanotech is affecting many industries across the value chain
- The impact on consumer products is very diverse, and “nano” is often not visible to the consumer
- EHS risks need attention, but can be managed responsibly

Thank you

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