

# Near-Term Commercial Opportunities in Nanotechnology

Presented by Scott Mize

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[www.scottmize.com](http://www.scottmize.com)



# Scott Mize

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- Co-founder of AngstroVision, Inc.
  - Tools Company – Nano-imaging Device
- Nanotechnology Opportunity Report™
  - Originator & Chairman of the Advisory Board
- Refocusing of Technanogy
  - From incubator to nanomaterials company
- Exclusive nanotech focus for over three years
- Tracking nanotech for over fifteen years



# Nanotechnology Definition

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- MANY definitions

“The technology of structuring and controlling matter on the scale of  $\sim 100\text{nm}$  and below.”

- Size gives rise to new properties
  - Quantum effects
  - New physical ratios/relationships



# Molecular Nanotechnology vs. Nanoscale Engineering

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- Engines of Creation
- Assemblers, replicators
- Nanorobots for medical applications
- Long term vs. short term



# Hype Backlash

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“Newest Silicon Valley Darling Lacks  
The Heft to Back Up Growing Hype”

“The Silicon Valley hype machine is gearing up  
to sell you a secondhand trend. Be careful, it  
may prove to be a lemon.”

-- Lee Gomes  
Staff Reporter, The Wall Street Journal  
May 6, 2002



# Nanoscale Engineering

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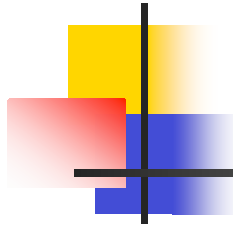
- Precursor to Molecular Nanotechnology
- Near Term – 0-3 Years
- Medium Term – 3-7 Years



# Where are We?

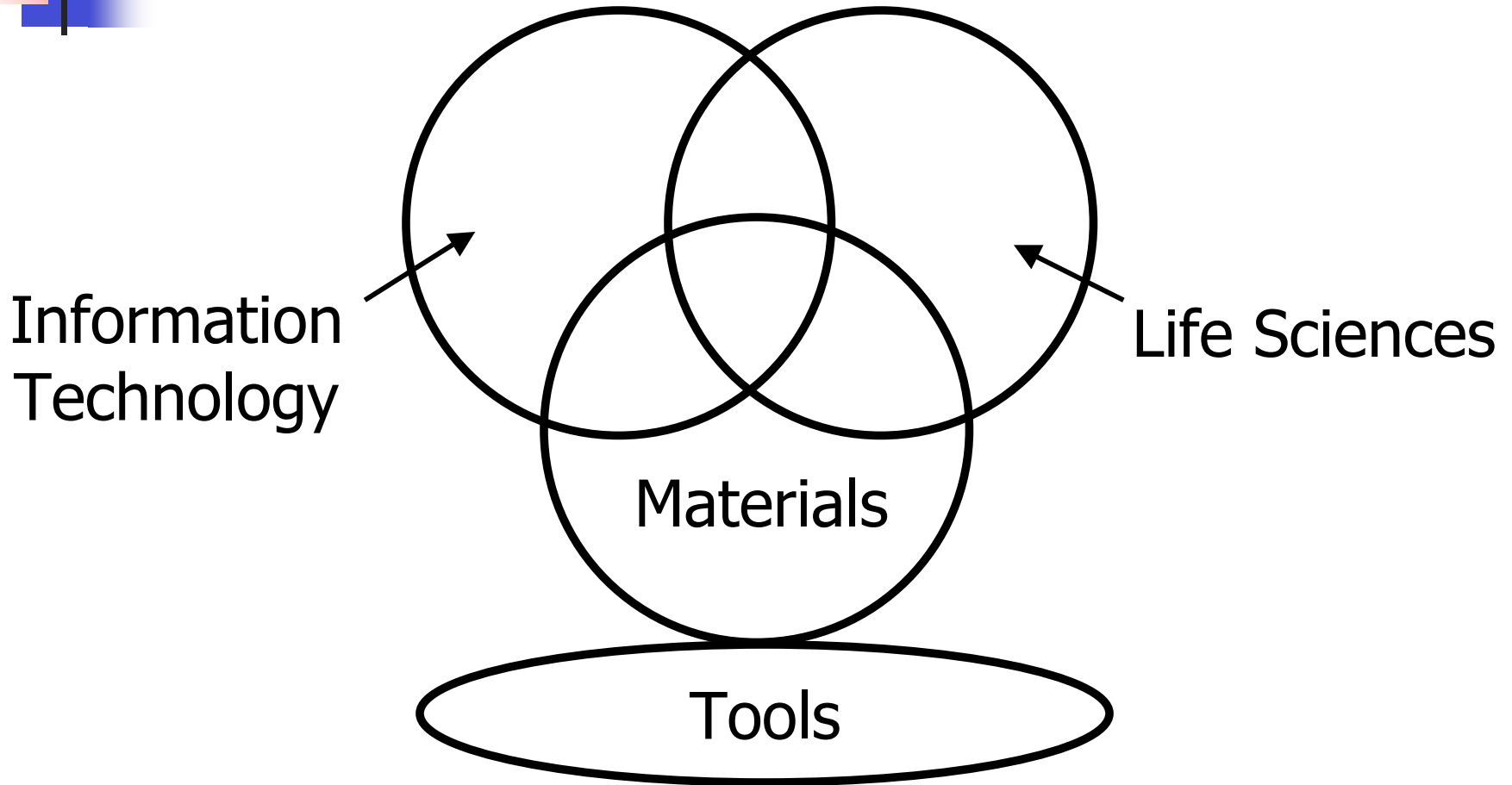
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- VERY early
- IT before the integrated circuit
  - Early 60's
- Biotech before recombinant DNA
  - Early 70's

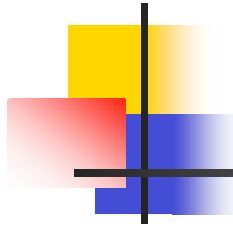


# The Nanotechnology Space

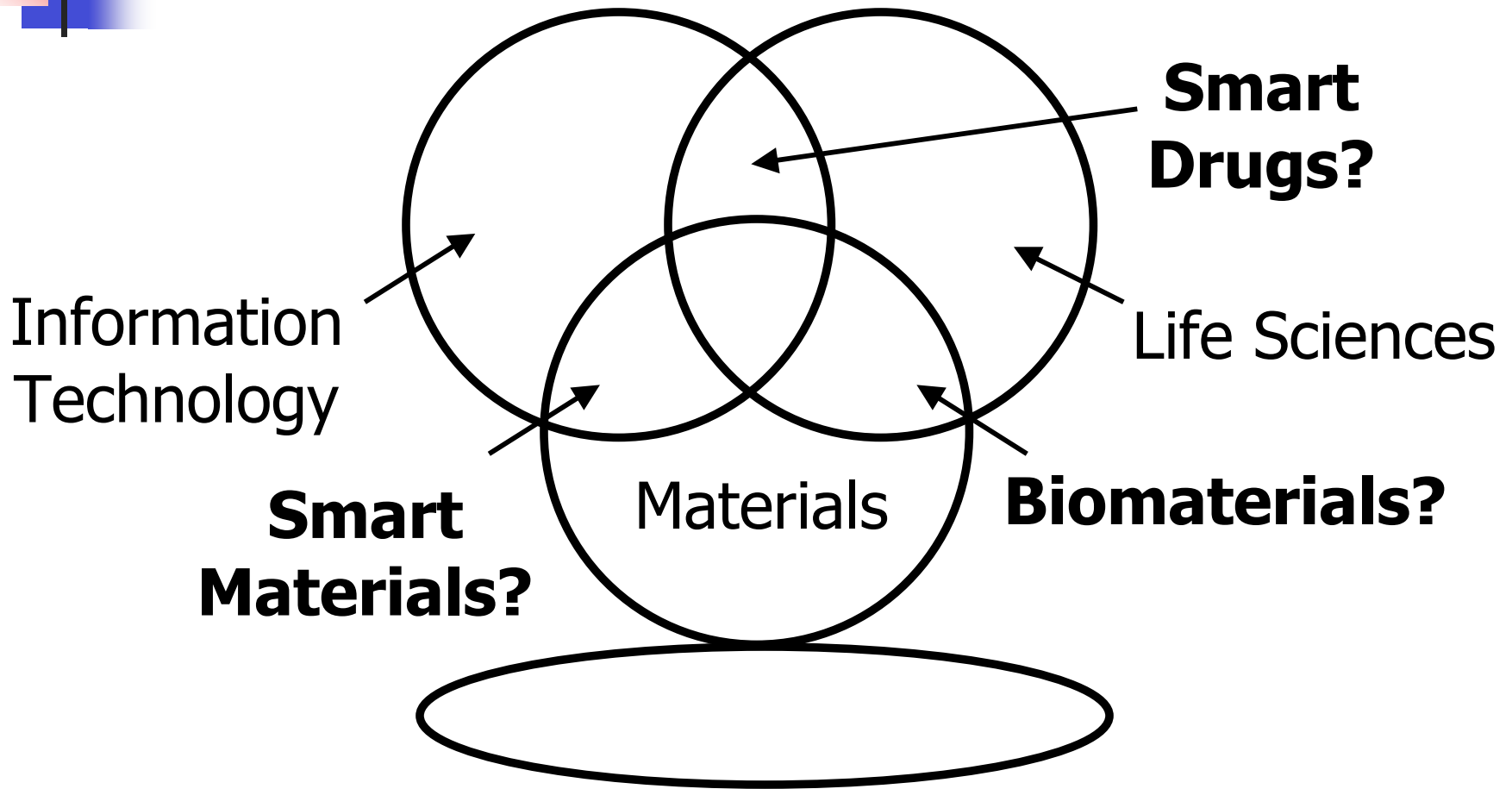
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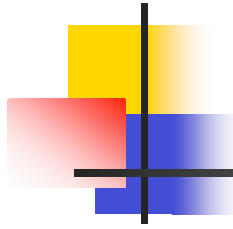






# The Nanotechnology Space



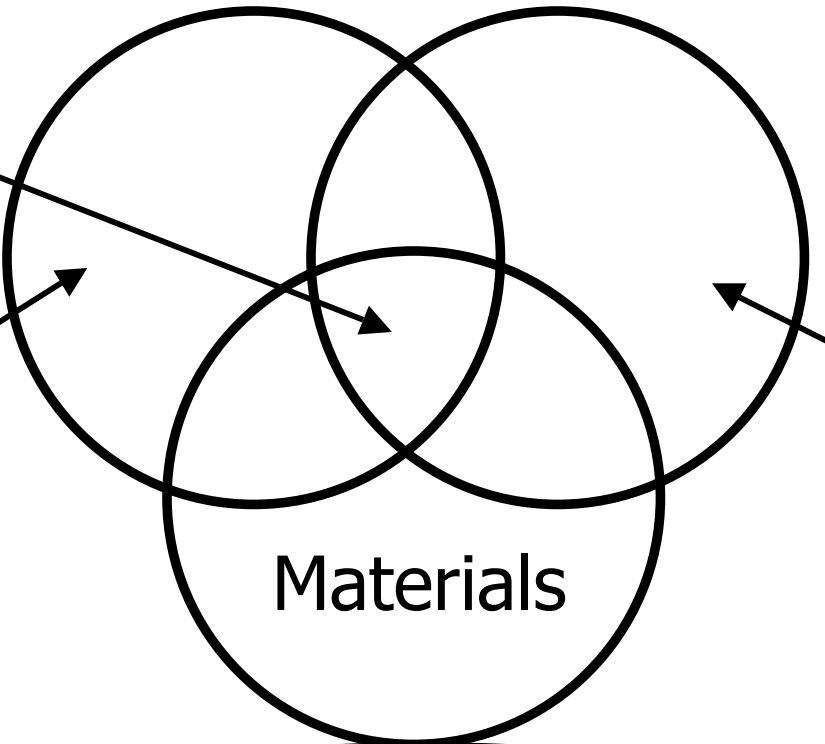


# The Nanotechnology Space

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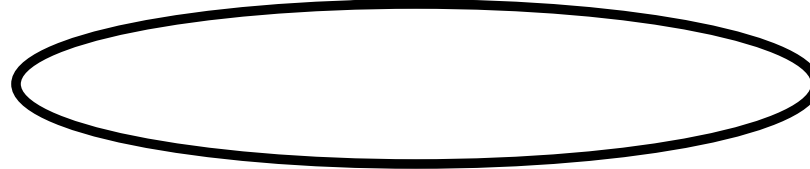
**Assembler?**  
**Replicator?**

Information  
Technology



Life Sciences

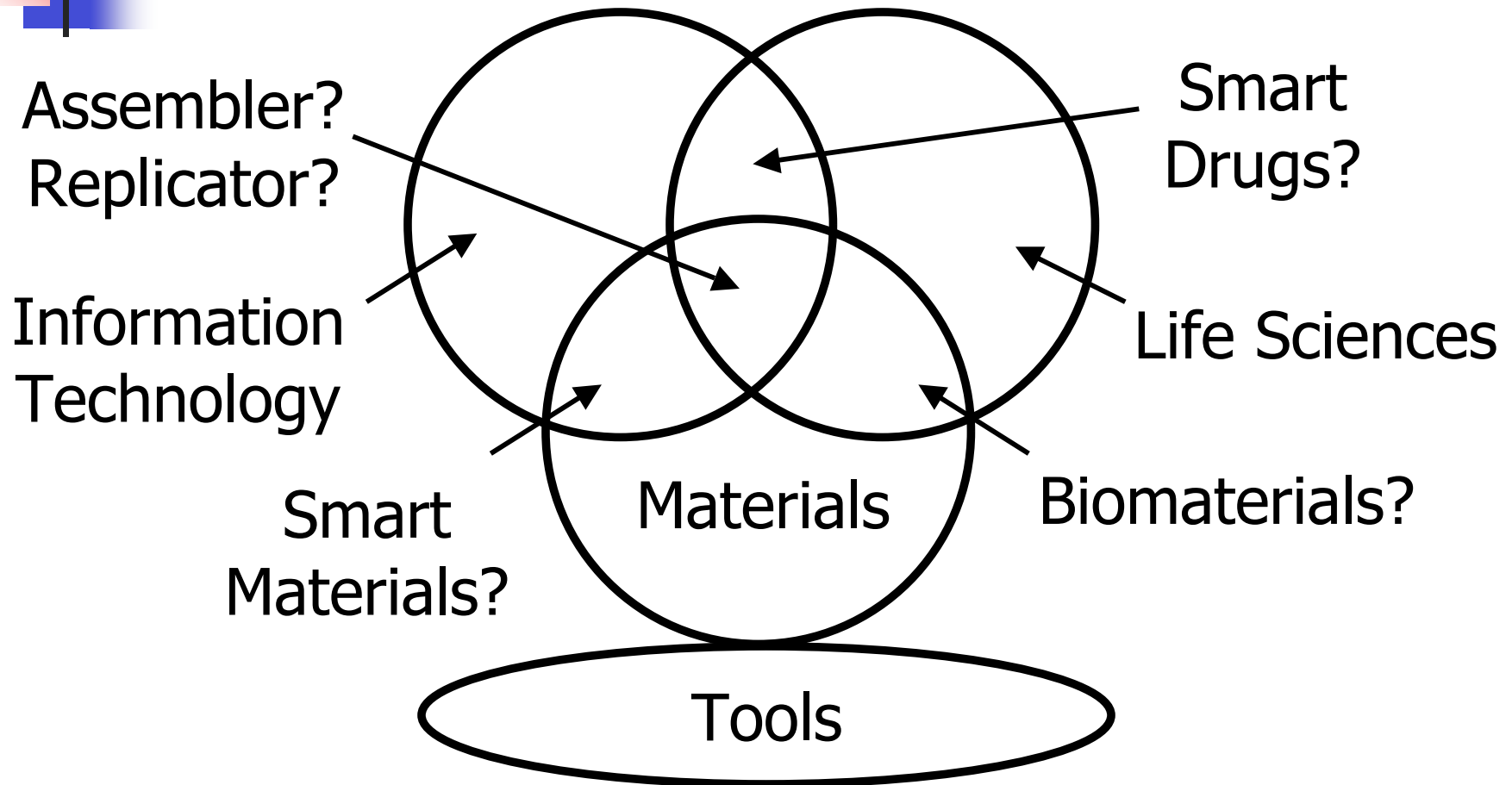
Materials





# The Nanotechnology Space

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# Progression of Opportunities

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- Tools – today, mature market
- Materials – today
  - (a.k.a. nanomaterials)
- Life Sciences – emerging
  - (a.k.a. nanobiotechnology, nanomedicine)
  - Smooth transition
- Information Technology – longer term
  - (a.k.a. molecular electronics/computing)

# Nanotechnology Opportunity Report™

- 600+ pages, 2 volumes
- Global overview of the field
- Funding – govt & private
- Technologies perspective
- Applications perspective
- Directory of Players
  - 700+ Companies
  - 300+ Research institutions
  - 150+ Investors





# Key Findings & Trends - 1

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- It's NOT science fiction – it's here today
  - Pants, trucks, tennis rackets, sunscreen & ski wax
- Will affect almost everything over time
- R&D funding is unprecedented
  - Majority of activity today is in research today
  - Academic, government and industrial
- Patent filing exploding worldwide
- Accelerated pace of development
  - Advances in tools will speed acceleration



## Key Findings & Trends - 2

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- Start of commoditization in some categories
- Competing innovations on multiple fronts
- Emerging focus on applications
  - Crossing chasm - R&D to manufacturing scale-up
- Spread across globe
  - Regions ~even if tools are factored out
- Many new institutes and centers of excellence



## Key Findings & Trends - 3

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- Inherently interdisciplinary
- Bottom up AND top down techniques
- Importance of self-assembly
- Connecting nano, micro and macro worlds
- Powerful innovations in overlapping areas
- Serious need for better educational programs
- Environmentalists are taking notice
  - Moratorium has been proposed





# Key Technologies

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- Nanotubes
- Fullerenes
- Nanoparticles
- Quantum Dot – Electronics & Photonics
- Dendrimers
- Soft Lithography
  - Nano-imprinting, Dip-pen lithography



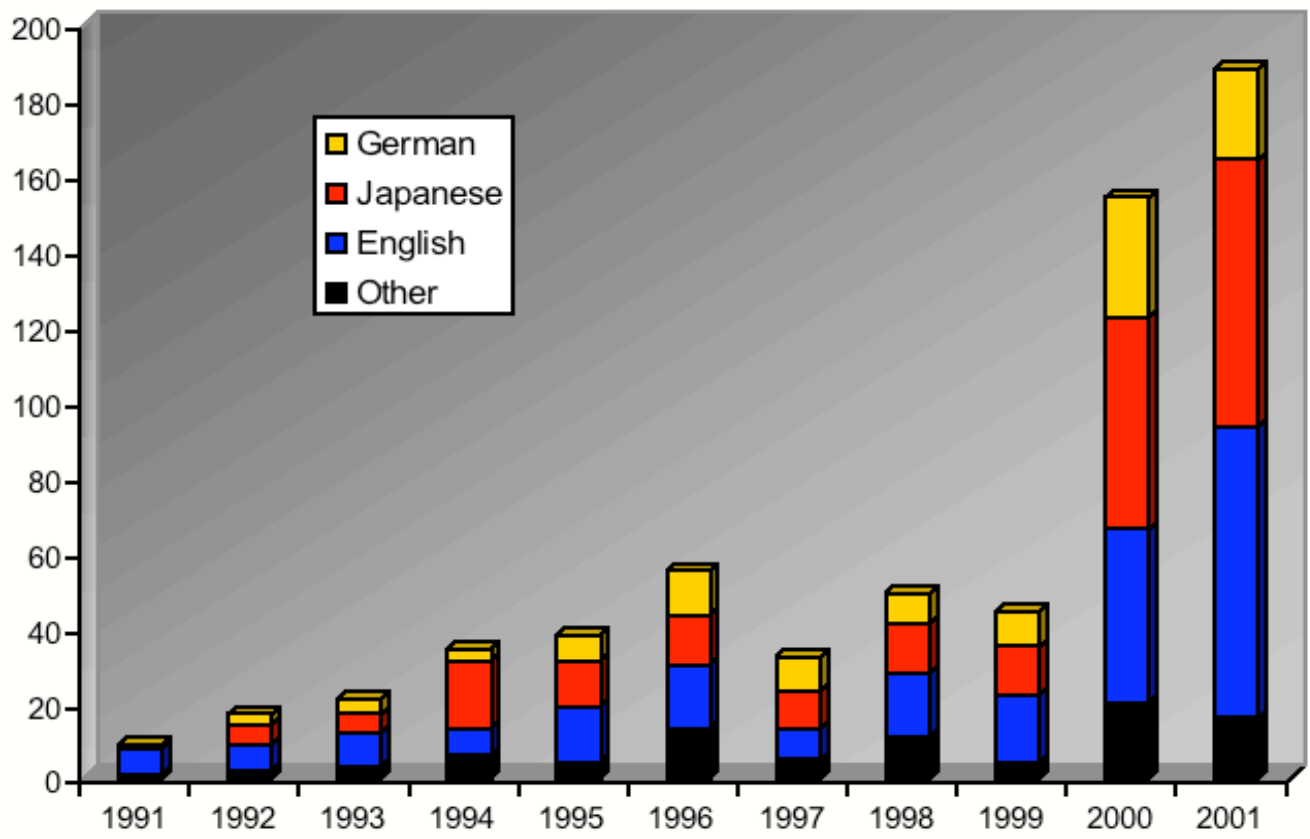
# R&D Funding – 2003 Estimate

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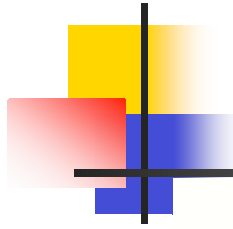
- Government

- U.S. \$0.8B+
- Asia \$1.8B+
- Europe \$1.0B+
- Total \$3.6B+

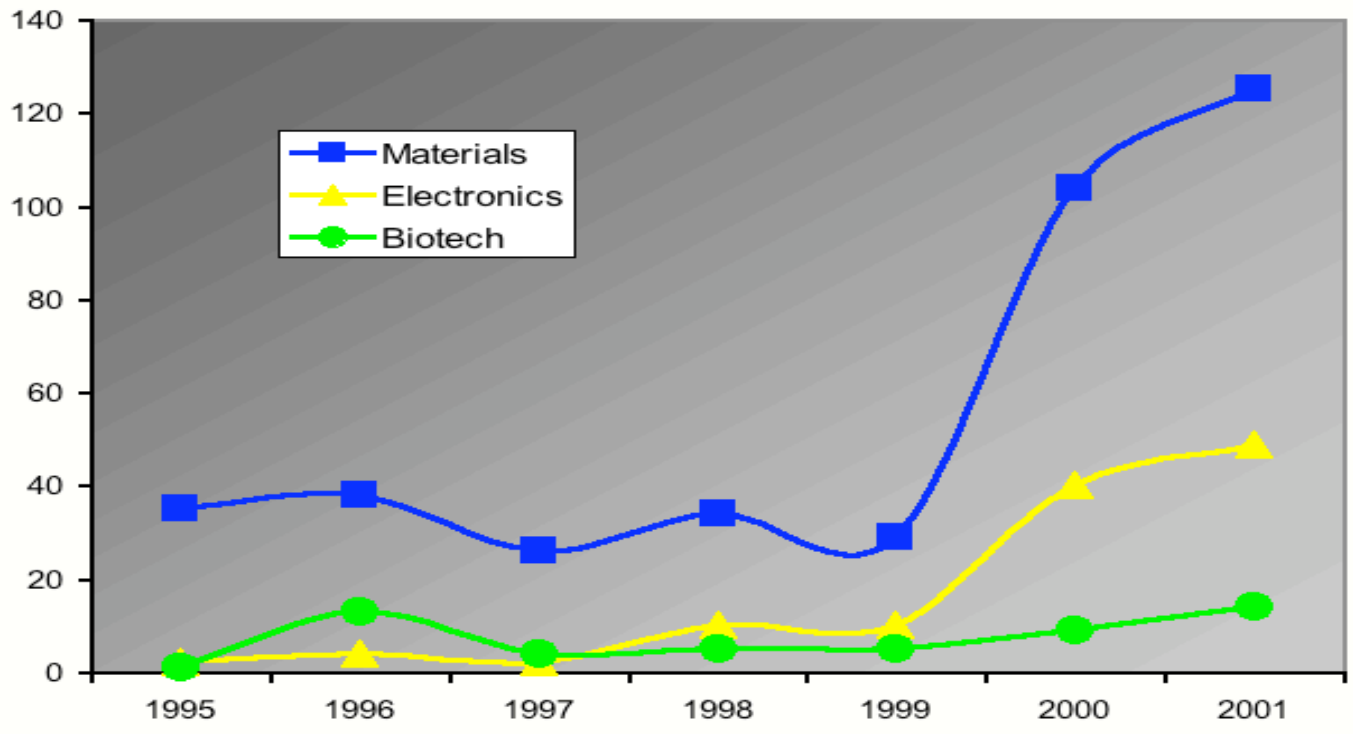
- Corporations spend approximately the same amount



Source: Polytechnos



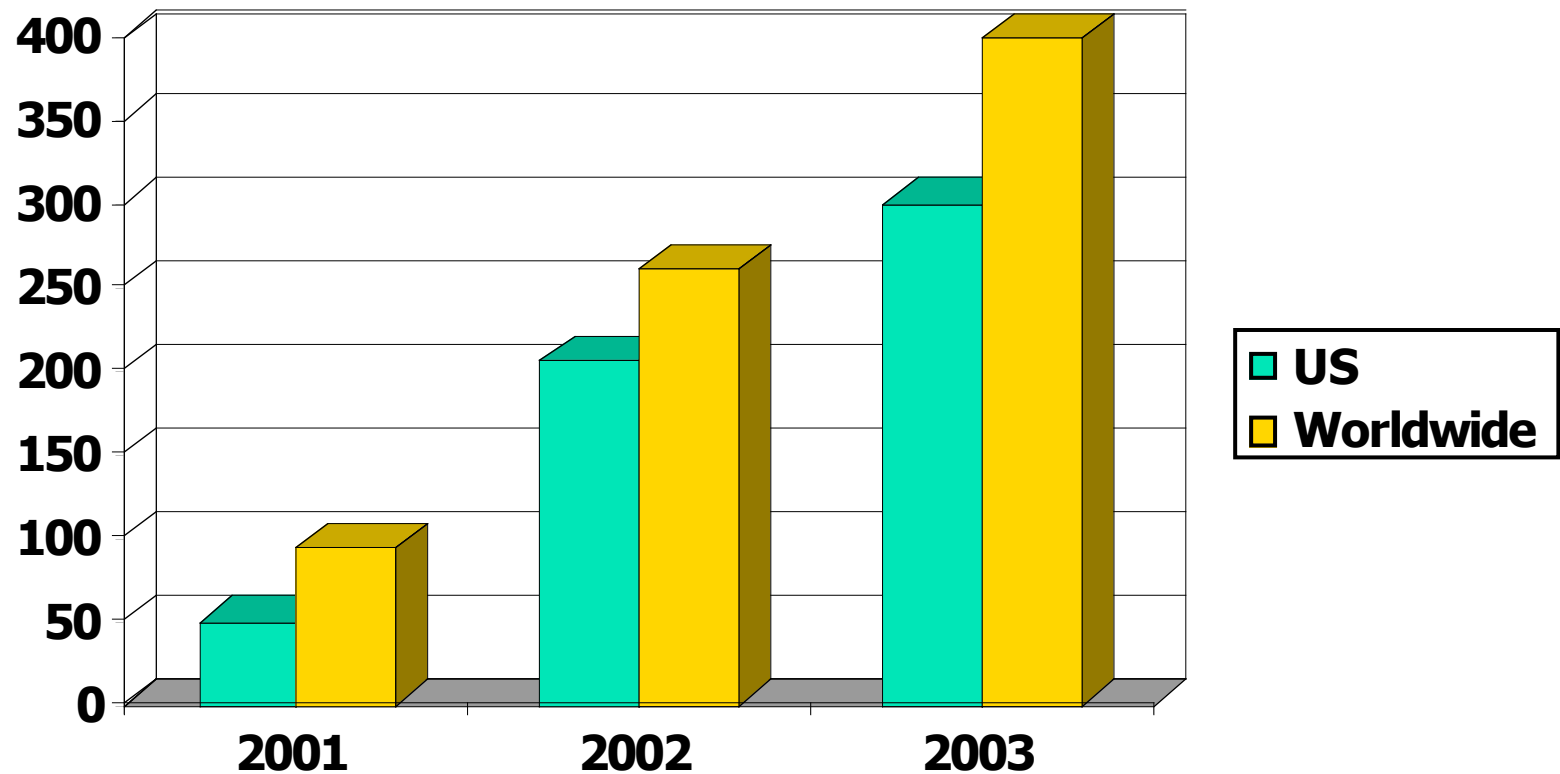
# Patents by Category



Source: Polytechnos



# Venture Capital Investment

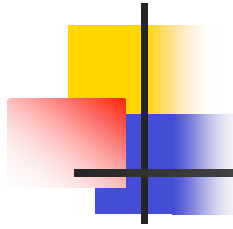




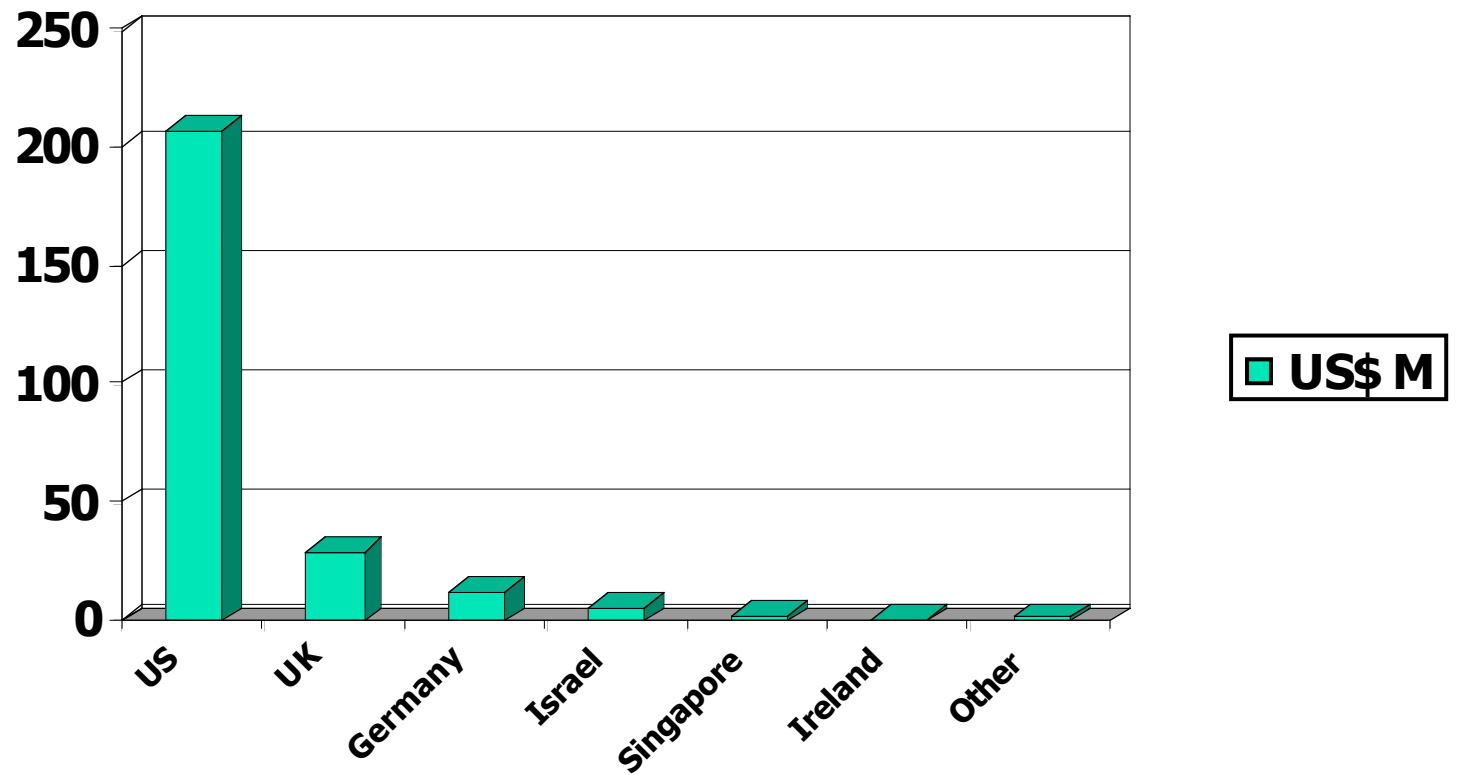
# Venture Capital Investment

<u>US\$M</u>	2001	2002	2003
US	50	207	300
Worldwide	95	262	400

Source: NOR, Small Times



# VC Funding by Country - 2002





# Wall Street Takes Notice

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- 4 Nanotech Indexes
  - Merrill Lynch (AMEX: NNX)
  - First Trust Portfolios (NASDAQ: FTNATX)
  - Punk Ziegel
  - Forbes/Wolfe Nanosphere
- Harris & Harris (NASDAQ: TINY)
- Morgan Stanley, CSFB, Legg Mason, ...





# Players by Type

	Large Companies	Subsidiaries & JVs	Small Companies	Research Institutions
North America	41	41	278	107
Europe	26	20	125	170
Asia	50	22	59	111



# Market Impact - Near Term

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- Tools
- Composite materials
- Coatings
- Catalysts



# Market Impact - Medium Term

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- Aerospace
- Medicine
  - Diagnostics, drug delivery
- Memories
- Display technologies
- Energy storage & distribution
  - Batteries, fuel cells, solar power



# Nanotech Giants

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- IBM ([www.ibm.com](http://www.ibm.com), IBM)
- HP ([www.hp.com](http://www.hp.com), HPQ)
- Intel ([www.intel.com](http://www.intel.com), INTC)
- General Electric ([www.ge.com](http://www.ge.com), GE)
- Cabot ([www.cabot-corp.com](http://www.cabot-corp.com), CBT)
- DuPont ([www.dupont.com](http://www.dupont.com), DD)
- BASF ([www.basf.com](http://www.basf.com), BF)
- Engelhard ([www.engelhard.com](http://www.engelhard.com), EC)
- Rohm & Haas ([www.rohmhaas.com](http://www.rohmhaas.com), ROH)
- Eastman Chemical ([www.eastman.com](http://www.eastman.com), EMN)
- Air Products ([www.airproducts.com](http://www.airproducts.com), APD)



# Tools

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- Scanning Probe Microscopes - SPM
- Near-Field Scanning Optical Microscopes - NSOM/SNOM
- Scanning Tunneling Microscopes - STM
- Atomic Force Microscopes – AFM
- Electron Microscopes - EM
- Focused Ion Beam – FIB
- New Interferometry Techniques
- Software



# Tools Companies

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- Veeco ([www.veeco.com](http://www.veeco.com), VECO)
- FEI Company ([www.feic.com](http://www.feic.com), FEIC)
- Applied Materials ([www.amat.com](http://www.amat.com), AMAT)
- KLA-Tencor ([www.kla-tencor.com](http://www.kla-tencor.com), KLAC)
- Agilent ([www.agilent.com](http://www.agilent.com), A)
- Nanometrics ([www.nanometrics.com](http://www.nanometrics.com), NANO)
- Hitachi ([www.hitachi-hitec.com/oversea](http://www.hitachi-hitec.com/oversea))
- JEOL ([www.jeol.com](http://www.jeol.com))
- Zyvex ([www.zyvex.com](http://www.zyvex.com))
- Arrayx ([www.arrayx.com](http://www.arrayx.com))
- NanoInk ([www.nanoink.net](http://www.nanoink.net))
- Molecular Imprints ([www.molecularimprints.com](http://www.molecularimprints.com))
- Pacific Nanotechnology ([www.pacificnanotech.com](http://www.pacificnanotech.com))
- Asylum Research ([www.asylumresearch.com](http://www.asylumresearch.com))



# Nanotech Software

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- Modeling, simulation, design
- Major work in academic institutions
- Nanomix
  - Materials discovery techniques
  - Similar to drug discovery
  - Moved away from this positioning



# Nanotech Software Companies

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- Accelrys ([www.accelrys.com](http://www.accelrys.com), PCOP)
- General Nanotech ([www.gennano.com](http://www.gennano.com))
- Hypercube ([www.hyper.com](http://www.hyper.com))
- Nanotitan ([www.nanotitan.com](http://www.nanotitan.com))
- Wavefunction ([www.wavefun.com](http://www.wavefun.com))
- Cadence/Celestry ([www.cadence.com](http://www.cadence.com), CDN)
- Synopsis/Numerical ([www.synopsis.com](http://www.synopsis.com), SNPS)





# Nanomaterials

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- Nanocrystalline materials
- Nanoparticles
- Nanocapsules
- Nanoporous materials
- Nanofibers
- Nanowires
- Fullerenes
- Nanotubes
- Dendrimers



# Nanoparticle Applications - 1

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- Composite materials
- Structural composites
- Packaging
- Coatings
- Fuel additives and explosives
- Abrasives
- Lubricants



# Nanoparticle Applications - 2

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- Drug delivery
- Antibacterial agents
- Bioanalysis & detection
- Catalysts
- Cosmetics
- Fuel cells & batteries
- Others



# Nanomaterials Companies

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- Nanophase ([www.nanophase.com](http://www.nanophase.com), NANX)
  - Nanoparticles for various applications (sunscreen)
- Oxonica ([www.oxonica.com](http://www.oxonica.com))
  - Nanoparticles for various applications (ski wax)
- Optiva ([www.optiva.com](http://www.optiva.com))
  - Thin crystal films for flat panel displays
- Symyx ([www.symyx.com](http://www.symyx.com), SMMX)
  - Novel materials discovery



# Nanomaterials Companies

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- Nanosys ([www.nanosysinc.com](http://www.nanosysinc.com))
  - Various nanostructures, many applications
  - Platform/IP play
- Nanomix ([www.nano.com](http://www.nano.com))
  - Nanotubes for sensors, energy
- Nano-Tex ([www.nano-tex.com](http://www.nano-tex.com))
  - Nanofibers for stain resistant fabrics
- AMCOL ([www.amcol.com](http://www.amcol.com), ACO)
  - Nanoclays for plastic nanocomposites



# Chemicals & Materials

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- Catalysts
- Membranes & Filtration
- Coatings & Paints
- Abrasives
- Lubricants
- Composites & Structural Materials



# Medical & Pharmaceutical

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- Detection, Analysis & Discovery
- Drug Delivery
- Prosthetics
- Anti-Microbial, -Viral, & -Fungal Agents



# Automotive & Transportation

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- DaimlerChrysler: 50 components of the automobile will be affected
  - Structural materials
  - Coatings
  - Sensors
  - Displays
  - Catalytic converters
  - Fillers
  - Power
  - Etc.



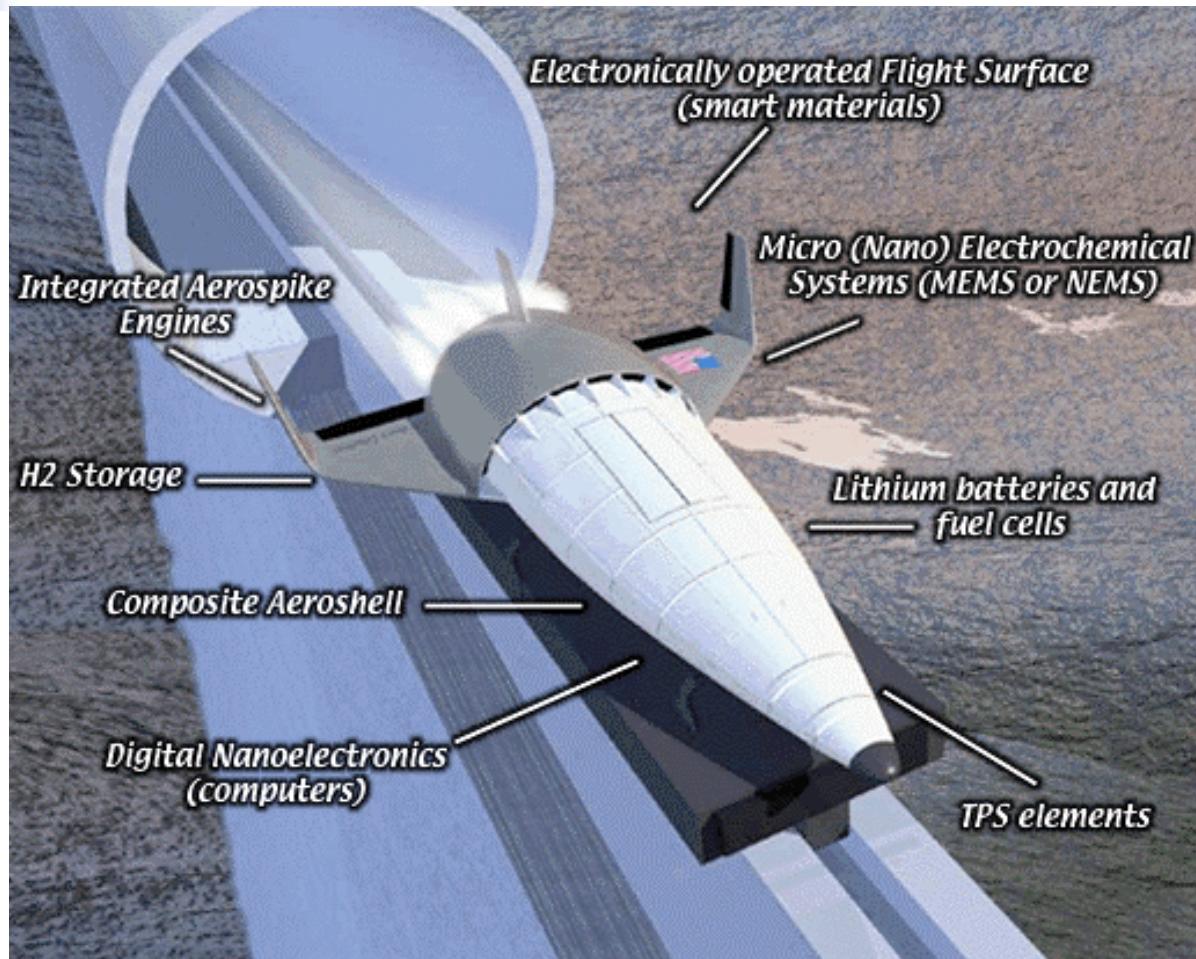


# Aerospace & Defense

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- Structural materials
- Coatings
- Fuel
- Electronics & electromechanical systems
- Weapons
- Surveillance
- Smart uniforms
- Life support and environmental

# Impact on a Space System



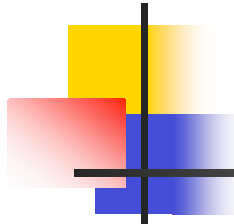
Source: NASA



# IT & Telecommunications

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- Photolithography
- Electronics & Optoelectronics
  - Processors
  - Data Storage, Molecular Memory
  - Display Technologies
- Quantum Computing
- Wireless Technologies
- Optical Transmission
- Optical Switching



# Energy

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- Fuel Cells
- Solar Power
- Rechargeable Batteries
- Power Transmission
- Lighting
- Energy Savings



# Energy Nanotech Companies

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- Konarka ([www.konarkatech.com](http://www.konarkatech.com))
- NanoSolar ([www.nanosolar.com](http://www.nanosolar.com))
- 3M ([www.3m.com](http://www.3m.com), MMM)
- General Hydrogen ([www.generalhydrogen.com](http://www.generalhydrogen.com))
  - General Motors Investment
- Hydrogen Solar ([www.h2spc.com](http://www.h2spc.com))
- Headwaters ([www.hdwtrs.com](http://www.hdwtrs.com), HDWR)
- Corning ([www.corning.com](http://www.corning.com), GLW)
- FMC Lithium ([www.fmclithium.com](http://www.fmclithium.com), FMC)
- ChevronTexaco ([www.chevrontexaco.com](http://www.chevrontexaco.com), CVX)
  - Molecular Diamond ([www.moleculardiamond.com](http://www.moleculardiamond.com))



# Data Storage

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- \$40B market
- Multiple technology approaches
  - IBM's Millipede – Cantilever Memory
    - Similar to AFM technology
    - ([www.zurich.ibm.com/st/storage/millipede.html](http://www.zurich.ibm.com/st/storage/millipede.html) )
  - Nanomagnetism ([www.nanomagnetism.com](http://www.nanomagnetism.com))
    - Magnetic memory
  - Nantero ([www.nantero.com](http://www.nantero.com))
    - Nanotube memory
  - NVE Corporation ([www.nve.com](http://www.nve.com), NVEC)
    - Spintronics-based MRAM



# Wireless Case Study

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- Displays
- Batteries
- Fuel cells
- Casing
- Circuit boards
- Memory
- Microprocessors
- ePaper



# Nanotechnology Conclusions

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- It's here today
- MNT is a longer -term
- Research funding is unprecedented
- It's Global – no one has clear lead
- Will affect almost everything
- Impact will be subtle and gradual
  - "Plastics"





# Resources

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- Links to nanotechnology Web sites
  - [www.scottmize.com](http://www.scottmize.com)
- Nanotechnology Opportunity Report™
  - [www.cientifica.com/html/NOR/NORV2.htm](http://www.cientifica.com/html/NOR/NORV2.htm)
- Forbes/Wolfe Nanotech Report
  - [www.forbesnanotech.com](http://www.forbesnanotech.com)
- Accelrys Nanotechnology Applications Guide
  - <http://nanotech.accelrys.com>
- Vision 2020 Roadmap for Nanomaterials
  - <http://chemicalvision2020.org/nanomaterialsroadmap.html>