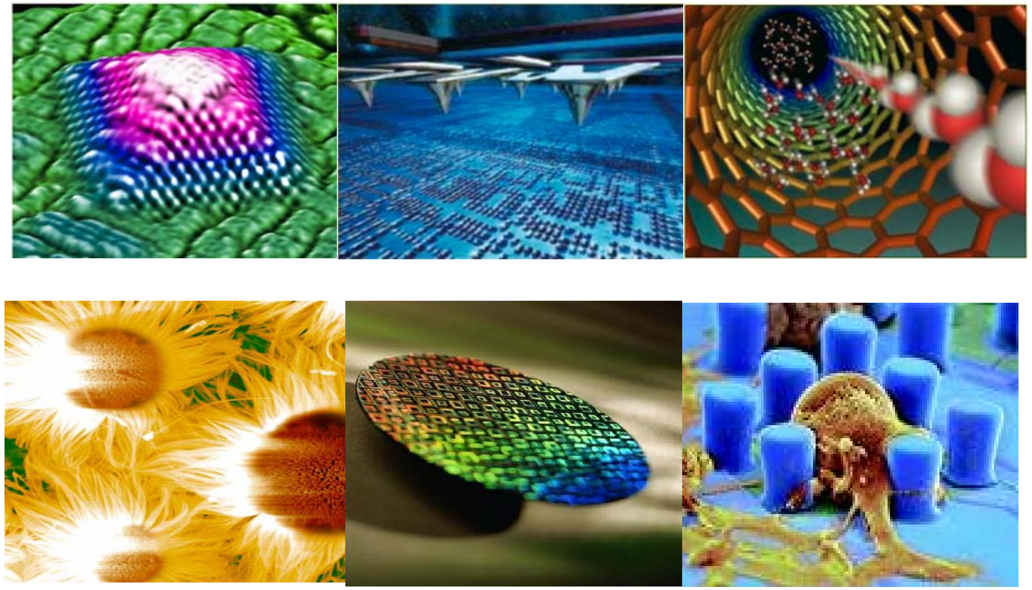
EAG POSITION PAPER
ON FUTURE R&D ACTIVITIES OF NMP
FOR THE PERIOD 2010 - 2015



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Scope of the Report

The priority R&D activities of the NMP Programme need to address the following two general issues, namely:

- Identification of research activities to support the European Industry to create new products / services and production paradigms, so that it can improve its competitiveness.
- Grand challenges in relation to Energy, Environment, Water, Food and Health related problems

Humanity's top five "Grand Challenges" for the next 50 years

- **Energy**
- **Water**
- **Food**
- **Health**
- **Environment**

NMP is part of the solution

The World Population

2003 6.5 billion
2050 8-10 billion

Source: Prof. R.E. Smalley, "Our Energy Challenge", Columbia University, NYC, 23 September 2003

Proposed Approach

For the preparation of the position paper, dealing with the above two issues, the following factors need to be addressed:

1. Present state-of-the-art in Europe and in the world in the respective field.
2. Required fundamental R&D activities in relation to the development of "breakthrough" technologies.
3. Present research priorities described in the most relevant ETPs.
4. Identification of the required advancements in selected industrial sectors.
5. Identification of possible synergies with other thematic priorities of the framework programme.
6. Expected impact (if possible, quantify the impact of the R&D activities in relation to an industrial sector, societal/economic impact, etc.)
7. Specify means for achieving the R&D objectives (EU projects, National projects, International projects, ERA-NET, etc.)
8. Establish appropriate performance indicators to monitor the progress of the programme and the correction/revision policies (if needed).

Future R&D Directions of NMP Programme

1. Introduction

2. Nanoscience and Nanotechnology

   2.1 Nanotechnology Products and Market Opportunities

   2.2 Present State-of-the-Art

   2.2.1 Nanomaterials and Nanostructures by Design

   2.2.2 Manufacturing of Nanostructures, Nanocomponents and Nanosystems

   2.3 Research Directions in Nanomaterials and Nanostuctures by Design

   2.3.1 Fundamental Understanding and Synthesis

   2.3.2 Analytical Nanotools and Measurements

   2.3.3 Manufacturing and Processing

   2.3.4 Modelling and Simulation

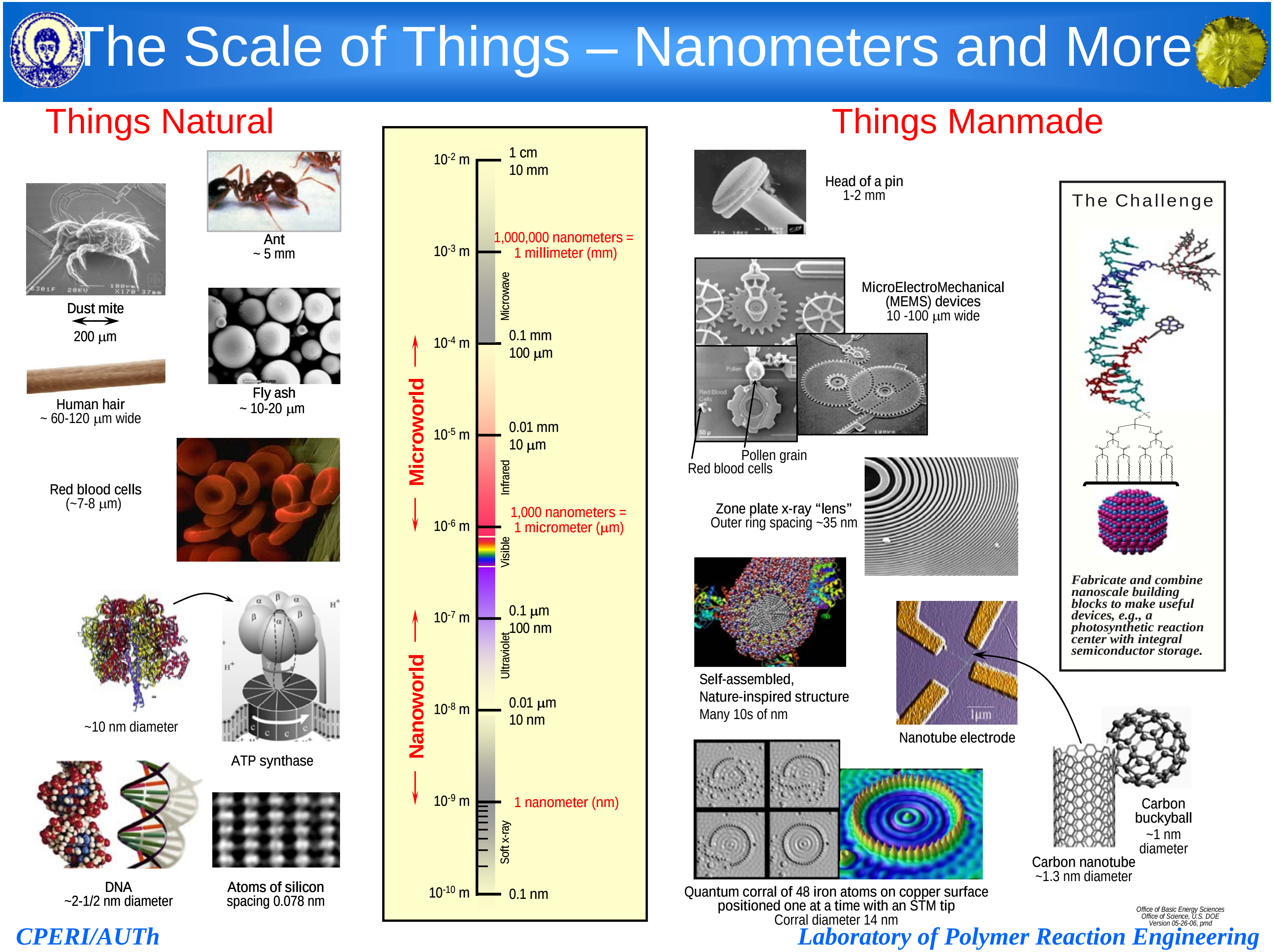
   2.3.5 Environment, Safety, and Health

   2.3.6 Standards and Informatics

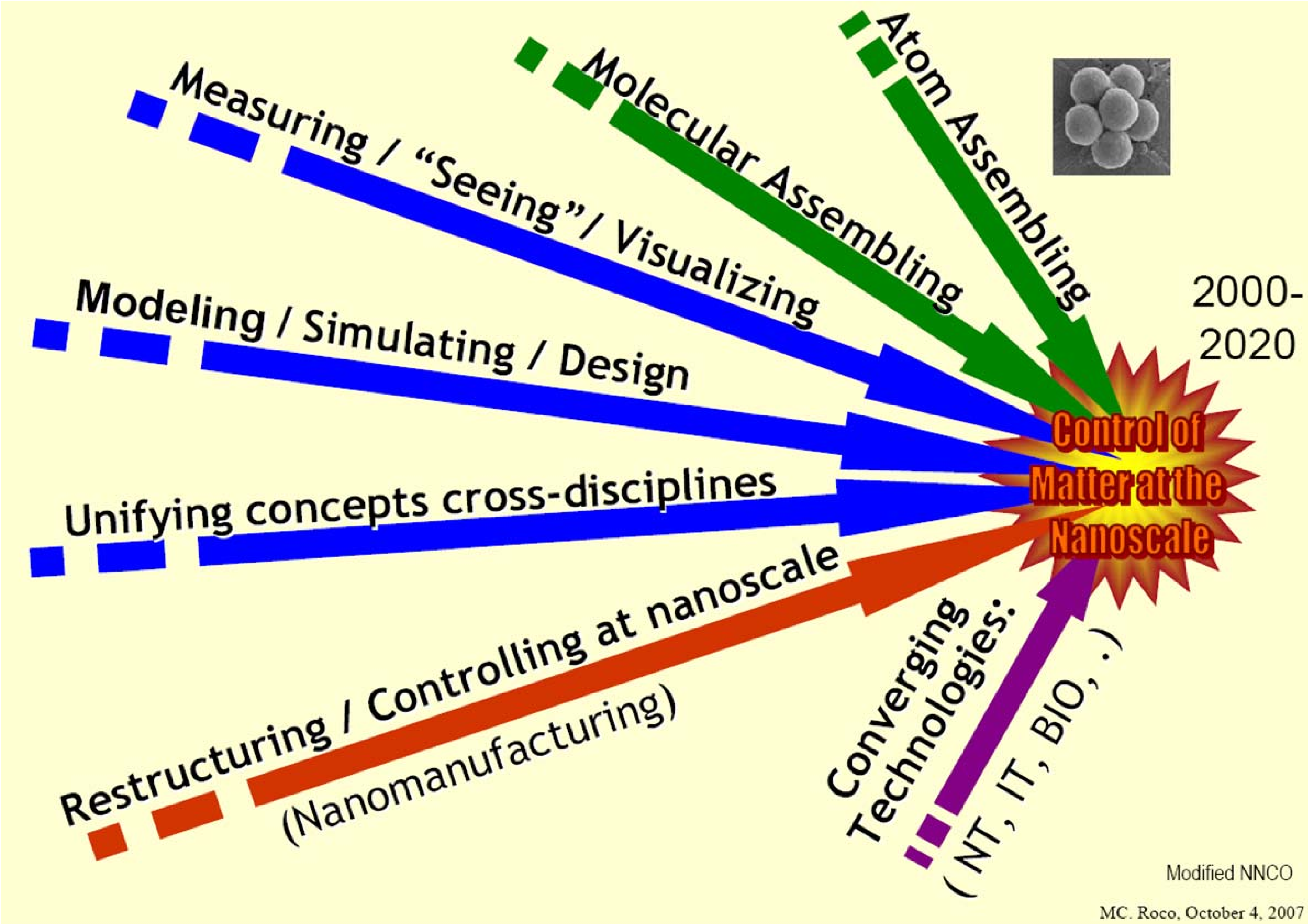
   2.3.7 Dissemination, Education and Training

Nanoscience and Nanotechnology

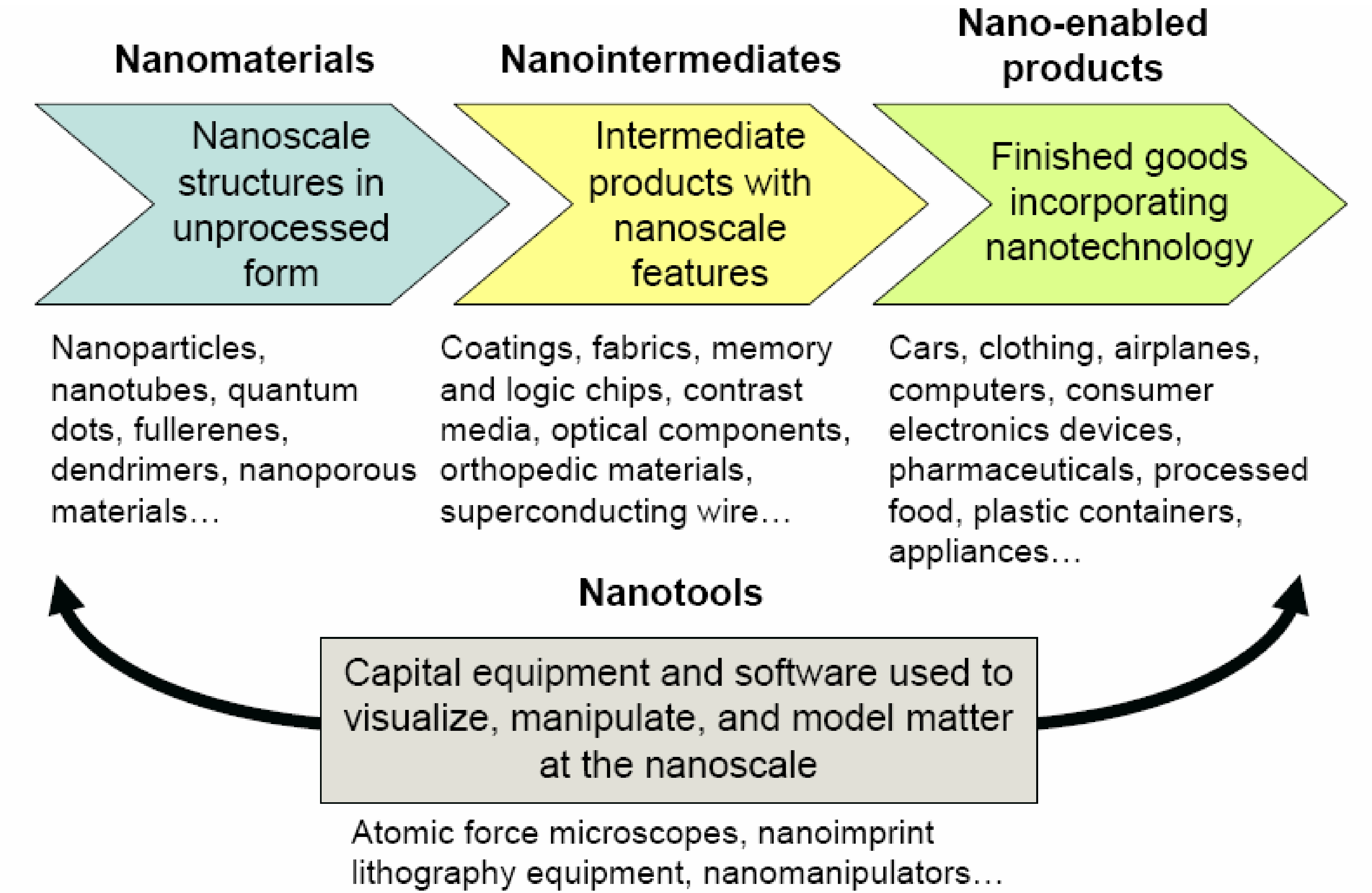
- Nanoscience and Nanotechnology are general terms that are employed to describe scientific and technological developments dealing with the synthesis, characterization, properties assessment and modelling as well as fabrication of functional nanomaterials, nanostructures, nanodevices and nanosystems.
- The true potential of nanotechnology is not yet exploited exhaustively.
- To overcome this and ensure that Europe will not stay behind in the global competition, a European Initiative is required that will bring together industry, research networks, NGO's at all levels for a joint movement towards a new industry.


The Scale of Things – Nanometers and More
Things Natural
Things Manmade
Dust mite
200 µm
Ant
~ 5 mm
Human hair
~ 60-120 µm wide
Fly ash
~ 10-20 µm
Red blood cells
(~7-8 µm)
~10 nm diameter
ATP synthase
DNA
~2-1/2 nm diameter
Atoms of silicon
spacing 0.078 nm
10-2 m
1 cm
10 mm
10-3 m
1,000,000 nanometers =
1 millimeter (mm)
Microwave
10-4 m
0.1 mm
100 µm
10-5 m
0.01 mm
10 µm
Infrared
10-6 m
1,000 nanometers =
1 micrometer (µm)
Visible
10-7 m
0.1 µm
100 nm
Ultraviolet
10-8 m
0.01 µm
10 nm
10-9 m
1 nanometer (nm)
Soft x-ray
10-10 m
0.1 nm
Microworld
Nanoworld
Head of a pin
1-2 mm
MicroElectroMechanical
(MEMS) devices
10 -100 µm wide
Pollen grain
Red blood cells
Zone plate x-ray "lens"
Outer ring spacing ~35 nm
Self-assembled,
Nature-inspired structure
Many 10s of nm
Nanotube electrode
Quantum corral of 48 iron atoms on copper surface
positioned one at a time with an STM tip
Corral diameter 14 nm
Carbon nanotube
~1.3 nm diameter
Carbon
buckyball
~1 nm
diameter
The Challenge
Fabricate and combine nanoscale building blocks to make useful devices, e.g., a photosynthetic reaction center with integral semiconductor storage.
Office of Basic Energy Sciences
Office of Science, U.S. DOE
Version 05-26-06, pmd
CPERI/AUTh
Laboratory of Polymer Reaction Engineering

Concurrence of Nanotechnology Capabilities



Nanotechnology Value Chain of Consumer Products

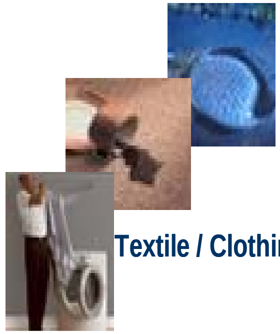


Nanotechnology Products

Nano iPod

MacBook Air

Glass
Photo / Self Cleaning

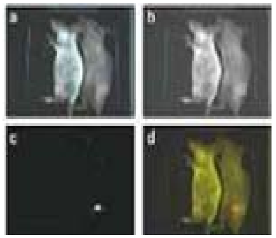


Textile / Clothing

CNT Bat

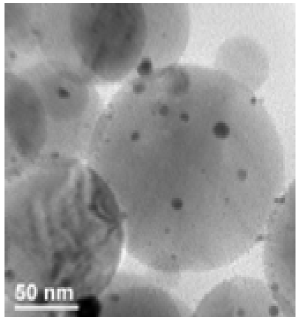
Cosmetics

Automotive Applications



Detection of Cancerous Cells

Tennis Racquet
Head Nano Titanium



Catalysts

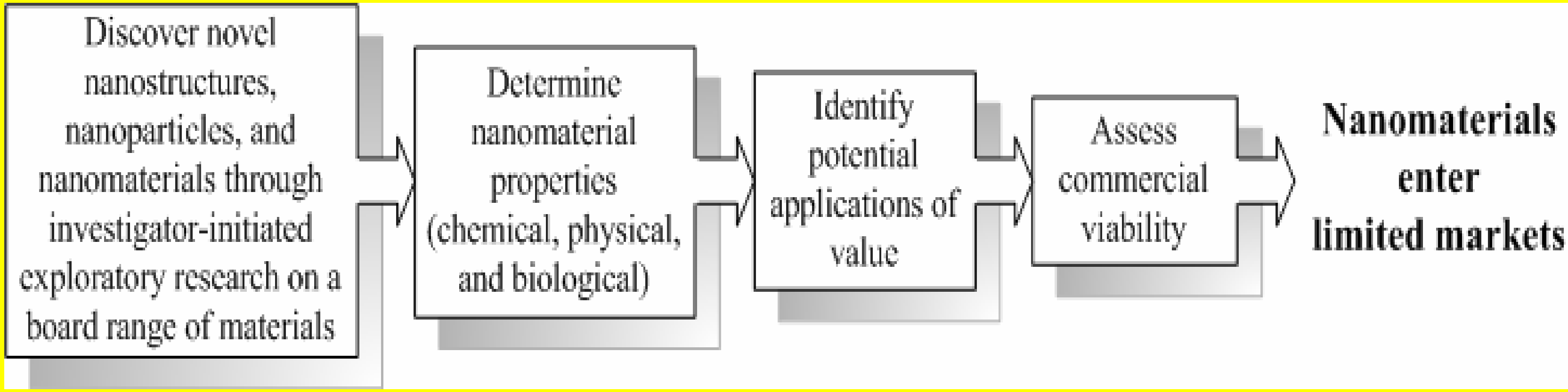
Anti Odor / Anti Bacterial Insoles for Shoes

Air Purification / NanoBreeze

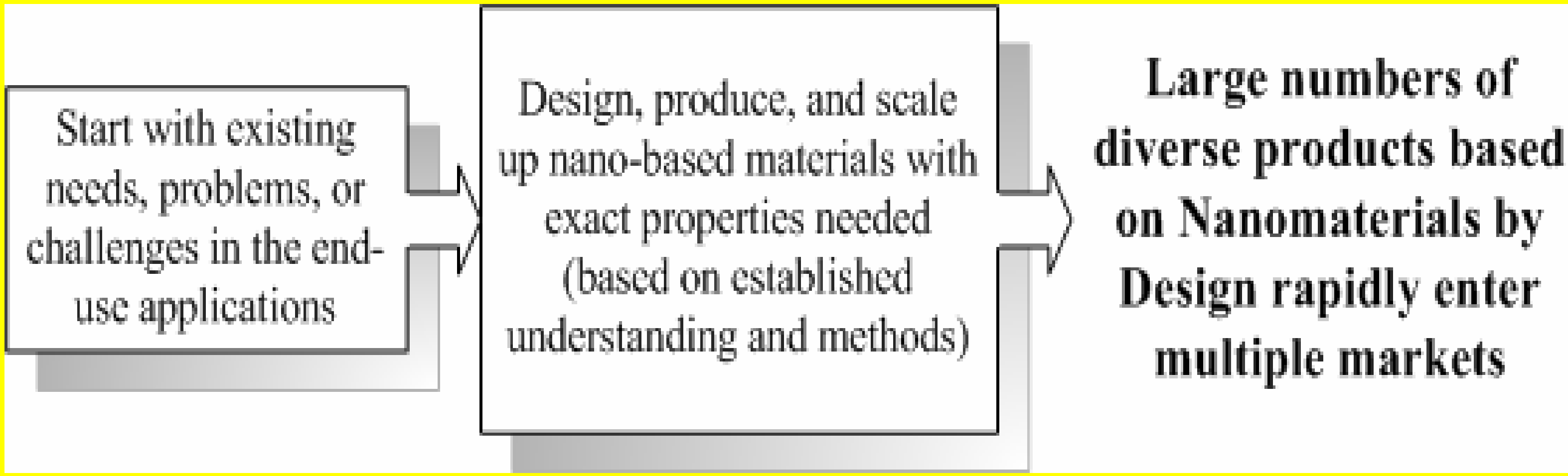
Chocolate Chewing Gum

Odorless socks

Present State of the Art

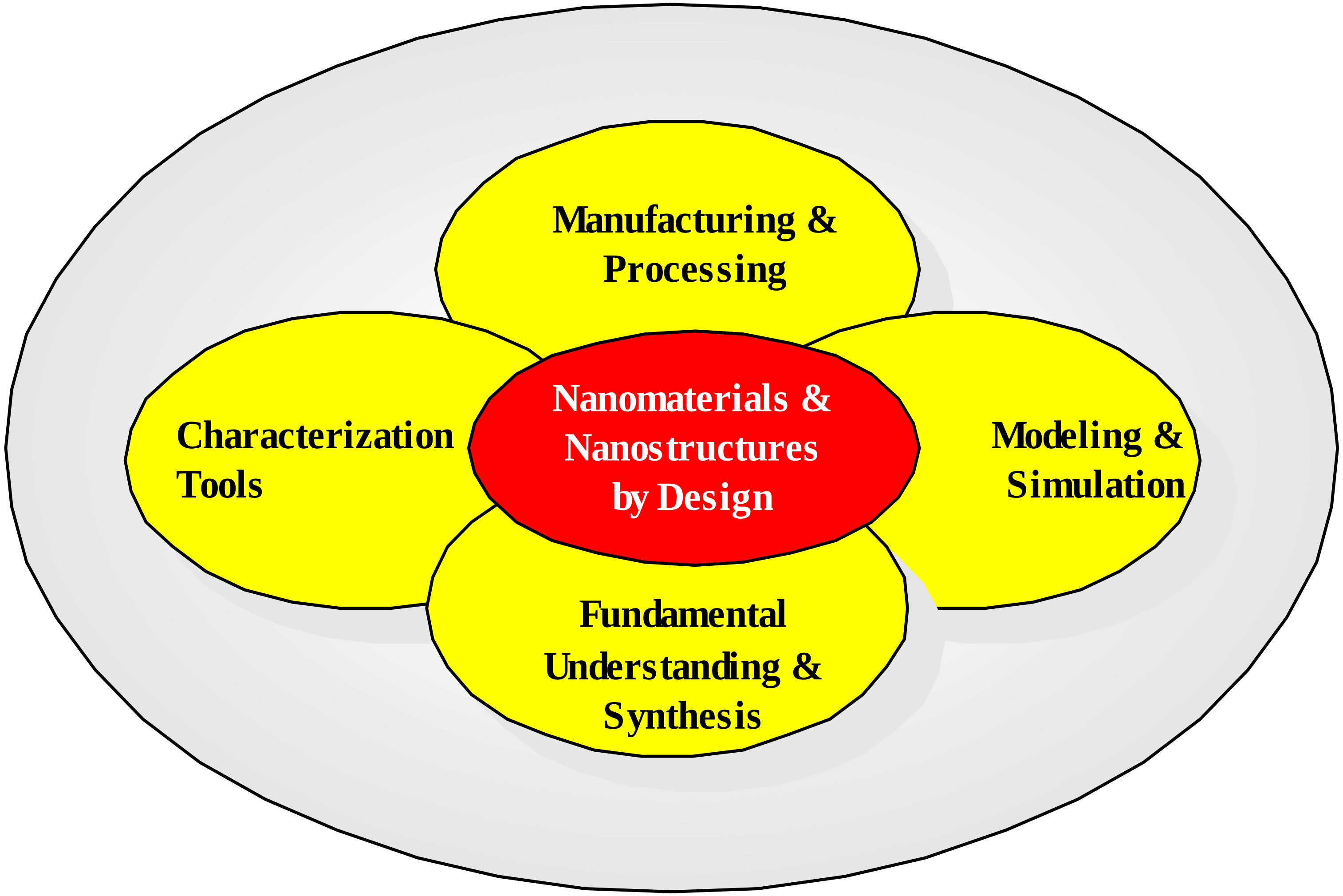


Today: Discovery-Based Science and Product Development

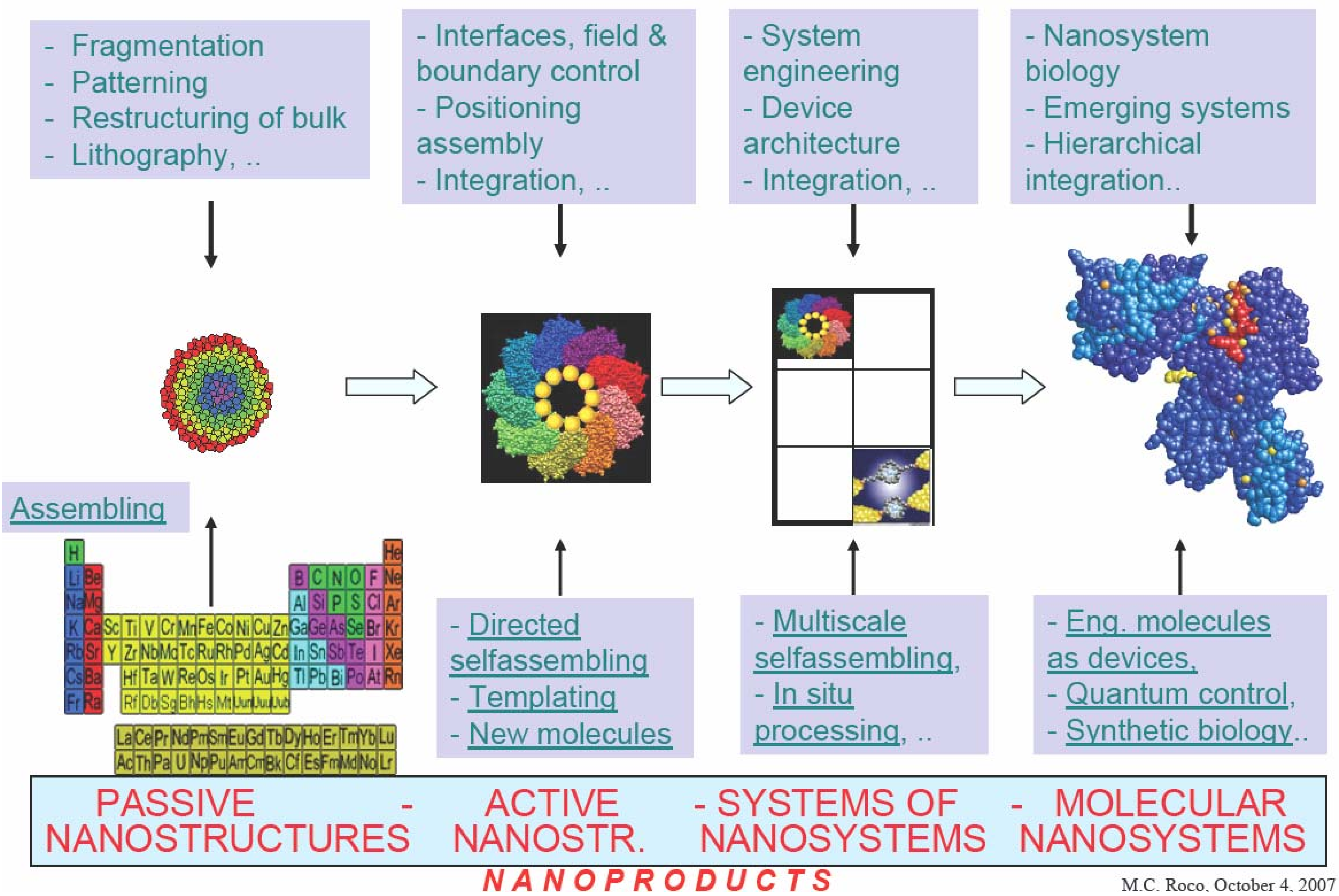


Future: Application-Based Problem Solving

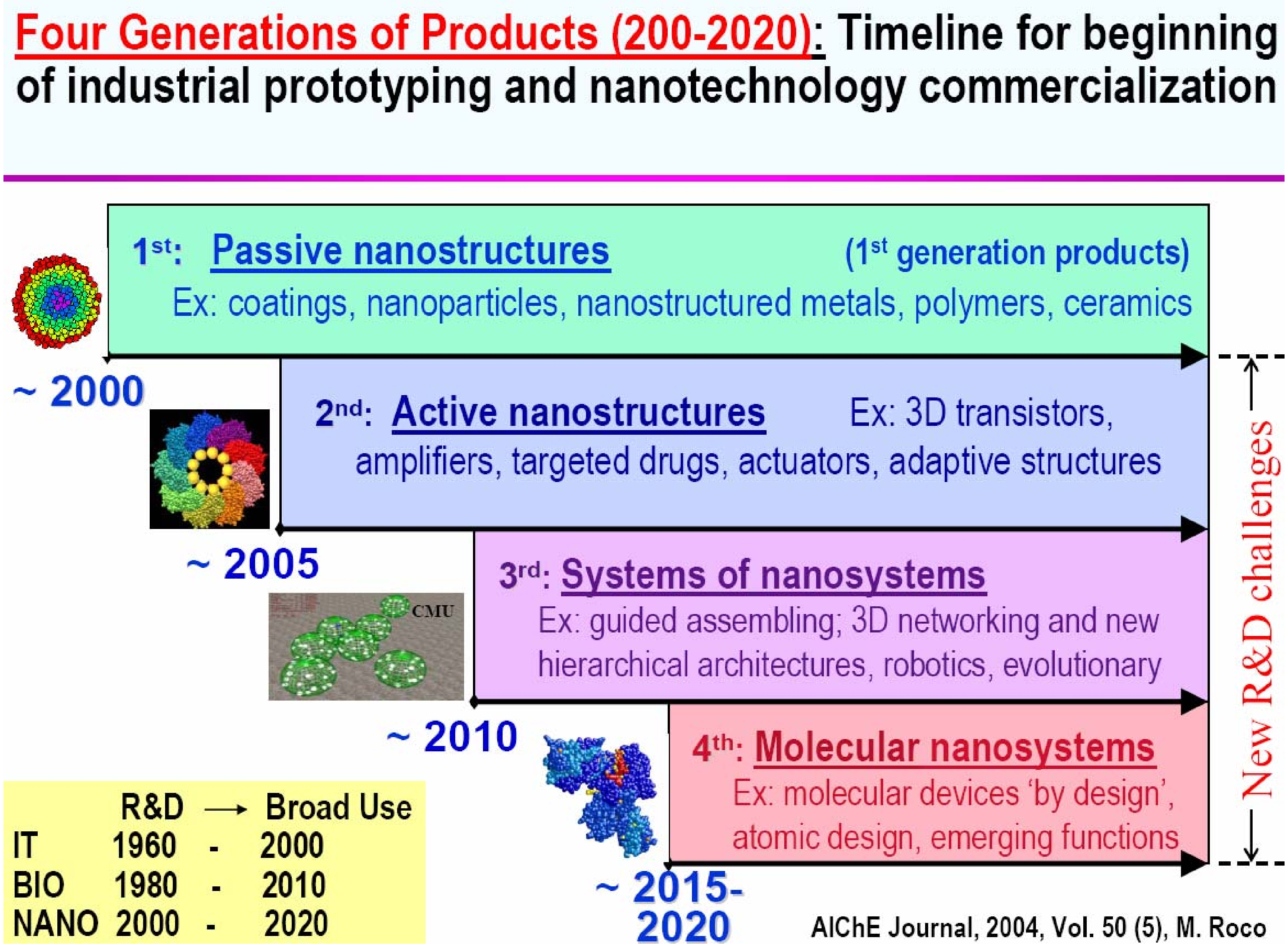
From Functional Nanomaterials to Nanostructures



Defining Nanomanufacturing



Four Generations of Products (2000-2020)



2.4 Research Directions in Atomically Precise Fabrication Methods

2.4.1 Atomically Precise Self-Assembly

2.4.2 Organic Synthesis

2.4.3 Scanning-Probe Based Nanofabrication

2.4.4 Hybrid Fabrication

2.4.5 Atomically Imprecise Fabrication Methods

2.4.6 Challenges in Atomically Precise Manufacturing

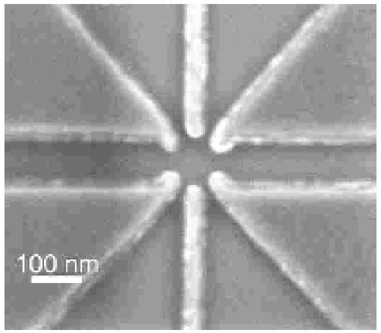
2.4.7 Challenges in Atomically Precise Components and Systems

2.4.8 Challenges in Fabrication Methods and Enablers

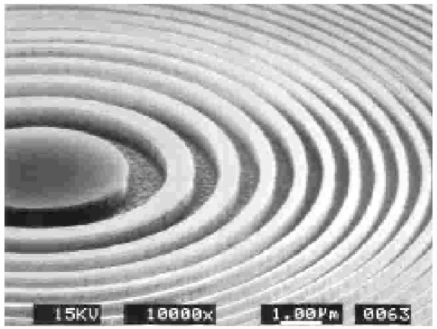
Research Directions in APFM

- Atomically Imprecise Fabrication Methods

  - ✓ Electron Beam Lithography
  - ✓ Block Copolymer Lithography
  - ✓ Nano-imprint Lithography
  - ✓ Dip-Pen Nanolithography
  - ✓ Dielectrophoretic Assembly
  - ✓ Plasmon Assisted Chemical Vapor Deposition (CVD)
  - ✓ Partially Ordered Chemical Self-Assembly



(a)



(b)

Expamples of nanostructures produced using e-beam lithograpy. (a) Ti/Al gate structures for a SET device generated by e-beam lithograph and lift-off, & (b) A bragg-Fresnel lens for x-rays exposed in continuous path control mode and etched into Si.

Research Directions in APFM

- Challenges in Atomically Precise Manufacturing

  - ✓ Challenges for Bio-Based APM of Large, Complex, Functional Nanosystems
  - ✓ Modular Molecular Composite Nanosystems (MMCNs)
  - ✓ Challenges for Tip-Based APM in Process Development and Scale-up
  - ✓ Position of APM in Current Nanotechnologies

- Challenges in Atomically Precise Components and Systems

  - ✓ Functional Elements and Systems Enabled by APM
  - ✓ Application Development Opportunities for APT

Research Directions in APFM

- Challenges in Fabrication Methods and Enablers

✓ Atomically Precise Tools

✓ Atomic Resolution Processes

✓ Atomically Precise Components and Building Blocks

✓ Modular Molecular Composite Nanosystems (MMCNs)

✓ Structures, Devices, and Systems

✓ Development of Scanning-Probe Based APM Systems

✓ Development of Early-Generation Productive Nanosystems

Atomically Precise Structural Control

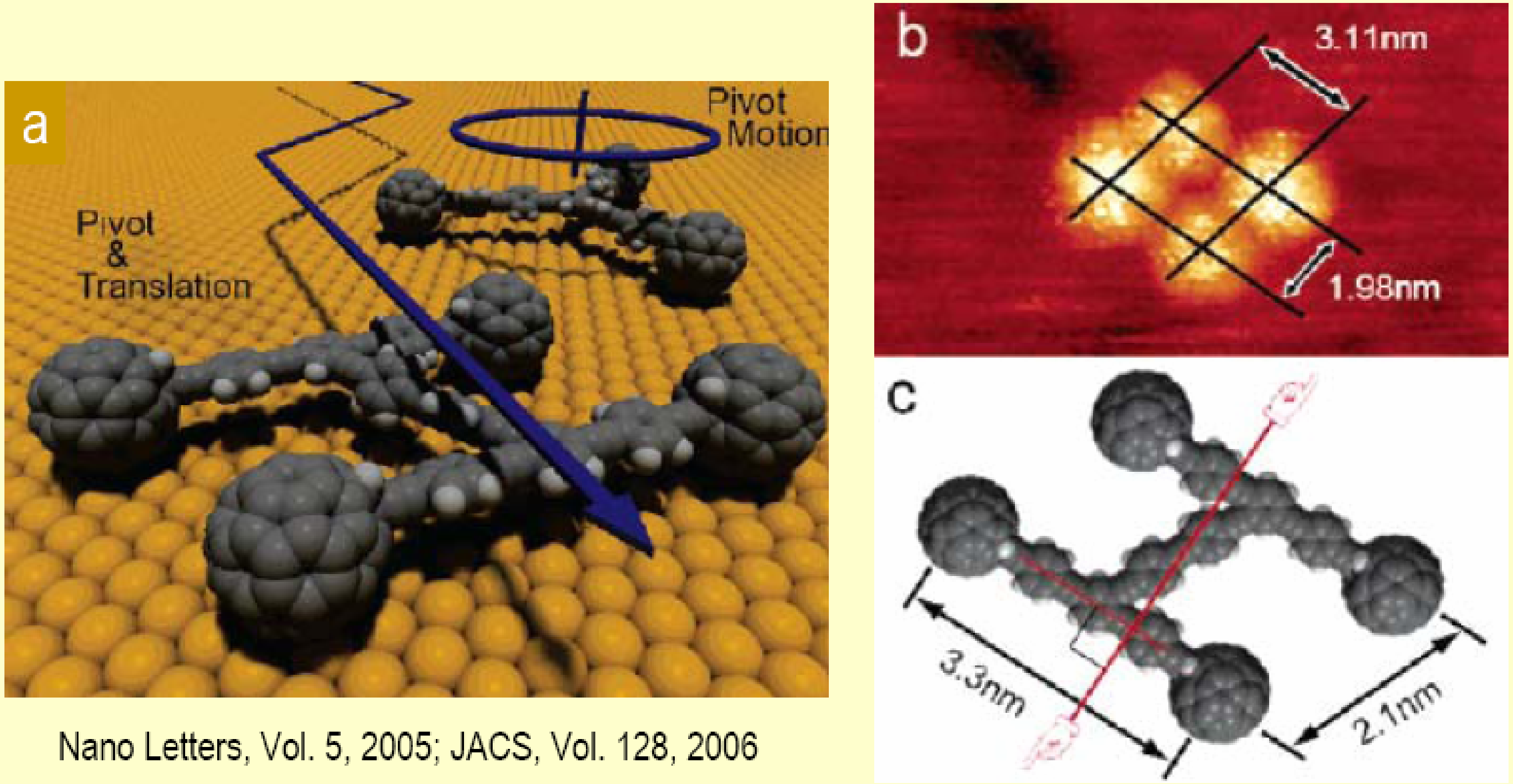
Aspect of atomic precision	Enabled features and applications
Precise internal structures	• Materials with novel properties (optical, piezoelectric, electronic...) with extremely broad applications • Defect-free materials that achieve their ideal strength, conductivity, transparency • Absence of statistical fluctuations in dopants enabling scaling to smaller gate size • 3D bandgap engineering for systems of quantum wells, wires, and dots • Systems of coupled spin centers for novel computer devices, quantum computing
Atomic-scale feature size	• High frequency devices, new sensors, high powerdensity mechanisms • High density digital circuitry, memory (up to ~10^{20} devices per cm^3)
Precise patterns of surface charge, polarity, shape, and reactivity	• Unique alignment of complementary surfaces for atomically precise self-assembly of complex, manycomponent structures • Precisely structured scanning-probe tips for atomically precise manufacturing, improved scanning probe microscopy • Molecular binding, sensing of specific biomolecules Stereospecific and chiral catalysis
Atomically smooth, regular surfaces	• Minimal scattering of electrons for low resistance nanowires, ideal electron optics • "Epitaxial" alignment of matching surfaces for atomically precise self-alignment, high-strength interfaces • Non-bonding, out-of-register surfaces for sliding interfaces with negligible static friction
Precisely identical structures	• System designs can exploit fine-tuning of properties • System designs can exploit symmetries among identical components • Reproducible behavior simplifies fault identification

Atomically Precise Manufacturing and Future Applications

Development Area	Horizon I	Horizon II	Horizon III
Atomically Precise Fabrication and Synthesis Methods	• Bio-based productive nanosystems (ribosomes, DNA polymerases) • Atomically precise molecular selfassembly • Tip-directed (STM, AFM) surface modification • Advanced organic and inorganic synthesis	• Artificial productive nanosystems in solvents • Mechanically directed solutionphase synthesis • Directed and conventional selfassembly • Crystal growth on tip-built surface patterns • Coupled-catalyst systems	• Scalable productive subsystems in machine-phase environments • Machine-phase synthesis of exotic structures • Multi-scale assembly • Single-product, high-throughput molecular assembly lines
Atomically Precise Components and Subsystems	• Biomolecules (DNA- and proteinbased objects) • Surface structures formed by tipdirected operations • Structural and functional nanoparticles, fibers, organic molecules, etc.	• Composite structures of ceramics, metals, and semiconductors • Tailored graphene, nanotube structures • Intricate, 10-nm scale functional devices	• Nearly reversible spintronic logic • Microscale 1 MW/cm3 engines and motors • Complex electro-mechanical subsystems • Adaptive supermaterials
Atomically Precise Systems and Frameworks	• 3D DNA frameworks, 1000 addressable binding sites • Composite systems of the above, patterned by DNA-binding protein adapters • Systems organized by tip-built surface patterns	• Casings, “circuit boards” to support, link components • 100-nm scale, 1000-component systems • Molecular motors, actuators, controllers • Digital logic systems	• Complex systems of advanced components, micron to meter+ scale • 100 GHz, 1 GByte, 1 μm-scale, sub-μW processors • Ultra-light, super-strength, fracture-tough structures
Applications	• Multifunctional biosensors • Anti-viral, -cancer agents • 5-nm-scale logic elements • Nano-enabled fuel cells and solar photovoltaics, • High-value nanomaterials • Artificial productive nanosystems	• Artificial immune systems • Post-silicon extension of Moore’s Law growth • Petabit RAM • Quantum-wire solar photovoltaics • Next-generation productive nanosystems	• Artificial organ systems • Exaflop laptop computers • Efficient, integrated, solar-based fuel production • Removal of greenhouse gases from atmosphere • Manufacturing based on productive nanosystems

Representative Molecular Motors, Actuators, and Mechanical Devices

Device	Function
Nanotube Nanomotor	Motor with MWNT serving as a bearing for the rotor and as an electrical conductor
Molecular Actuator	Molecular actuator able to reversibly push apart two carbon nanotubes
Molecular Seal	Nanoseal that can be opened and closed at will to trap and release molecules – can be triggered and reversed by redox chemistry or changes in pH
Molecular Bearings	Nearly frictionless bearing made from two co-rotating nested nanotubes
Nanosprings	Lithographic methods were used to fabricate paddles or levers onto multiwall carbon nanotubes acting as torsional springs
Telescoping Arms	Manipulator capable of extending the inner nanotube in a MWNT
Biomotors	Molecular motors evolved by nature that perform a variety of mechanical tasks
"Nanocar"	Molecular Feringa motor rotates and pushes a protruding molecular group against a substrate, propelling a molecular chasis forward along an atomically flat surface, powered by 365 nm wavelength light
DNA-based robotic arm	DNA-based robot arm inserted into a 2D array substrate and verified by atomic force microscopy to be a functional nanomechanical device with a fixed frame of reference
Molecular carrier	A molecule called 9,10-dithioanthracene (DTA) with two "feet". Activated by heat or mechanical force, DTA will pull up one foot, put down the other, and walk in a line across a flat surface w/o tracks. Can carry molecular payloads of CO_2.
Molecular rack and pinion	A STM tip drives a single 1.8-nmdiameter pinion molecule functioning as a six-toothed wheel interlocked at the edge of a self-assembled molecular island acting as a rack. The rotation of the pinion molecule is monitored by a chemical tag on one cog.



Nano Letters, Vol. 5, 2005; JACS, Vol. 128, 2006

Nano-cars driven by light-activated or thermally driven nanomotors
(rolling molecules)

Future R&D Directions of NMP Programme

2.5 Nanotechnology-related Environmental, Health and Safety Research

2.5.1 Environmental and Health Impact of Manufactured Nanomaterials

2.5.2 Assessing the Potential Adverse Effects of Nanomaterials

2.5.3 Threats Posed by Nanomaterials to Humans

2.5.4 Risk Management Methods

2.5.5 Regulatory Procedures

2.5.6 Priority Research Needs in EHS for Nanoscale Materials

2.5.7 Research Priorities in EHS

Priority EHS Research Needs for Engineered Nanoscale Materials

Instrumentation, Metrology, and Analytical Methods

- Develop methods to detect nanomaterials in biological matrices, the environment, and the workplace
- Understand how chemical and physical modifications affect the properties of nanomaterials
- Develop methods for standardizing assessment of particle size, size distribution, shape, structure, and surface area
- Develop certified reference materials for chemical and physical characterization of nanomaterials
- Develop methods to characterize a nanomaterial's spatio-chemical composition, purity, and heterogeneity

Nanomaterials and Human Health

Overarching Research Priority: Understand generalizable characteristics of nanomaterials in relation to toxicity in biological systems.

Broad Research Needs:

- Understand the absorption and transport of nanomaterials throughout the human body
- Develop methods to quantify and characterize exposure to nanomaterials and characterize nanomaterials in biological matrices
- Identify or develop appropriate in vitro and in vivo assays/models to predict in vivo human responses to nanomaterials exposure
- Understand the relationship between the properties of nanomaterials and uptake via the respiratory or digestive tracts or through the eyes or skin, and assess body burden
- Determine the mechanisms of interaction between nanomaterials and the body at the molecular, cellular, and tissular levels

Priority EHS Research Needs for Engineered Nanoscale Materials

Nanomaterials and the Environment

- Understand the effects of engineered nanomaterials in individuals of a species and the applicability of testing schemes to measure effects
- Understand environmental exposures through identification of principle sources of exposure and exposure routes
- Evaluate abiotic and ecosystem-wide effects
- Determine factors affecting the environmental transport of nanomaterials
- Understand the transformation of nanomaterials under different environmental conditions

Human and Environmental Exposure Assessment

- Characterize exposures among workers
- Identify population groups and environments exposed to engineered nanoscale materials
- Characterize exposure to the general population from industrial processes and industrial and consumer products containing nanomaterials
- Characterize health of exposed populations and environments
- Understand workplace processes and factors that determine exposure to nanomaterials

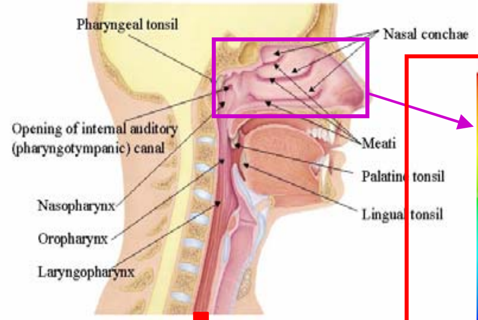
Risk Management Methods

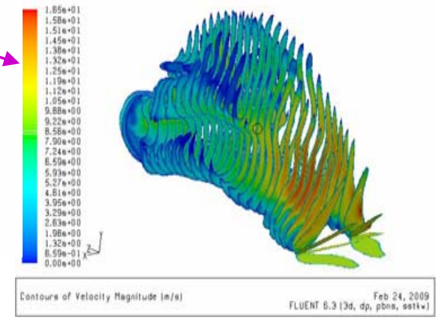
Overarching Research Priority: Evaluate risk management approaches for identifying and addressing risks from nanomaterials

- Understand and develop best workplace practices, processes, and environmental exposure controls
- Examine product or material life cycle to inform risk reduction decisions
- Develop risk characterization information to determine and classify nanomaterials based on physical or chemical properties
- Develop nanomaterial-use and safety-incident trend information to help focus risk management efforts
- Develop specific two-way risk communication approaches and materials

Drug Delivery in the Respiratory Tract

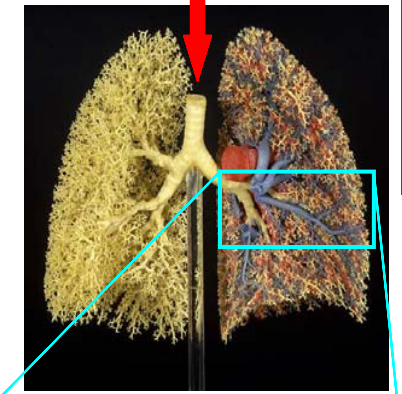
- A virtual physiological model of the respiratory system is being developed, including the nasal cavity, the pharyngotrachea, and the pulmonary tract (bronchi, bronchioli, and alveoli).
- CFD simulations of each respiratory compartment are performed and connected together through the inlet and outlet boundary conditions.
- Drug delivery models are developed providing the amount of drug released from deposited particles and droplets.





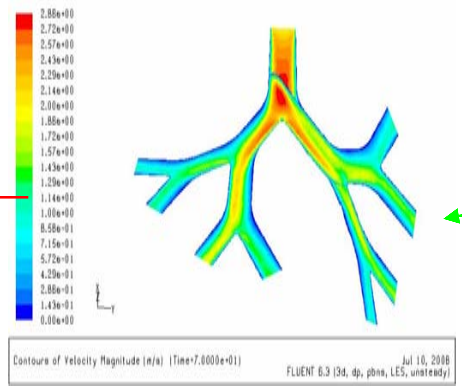
CFD Simulation of Nasal Cavity

Nasal Drug Delivery Model

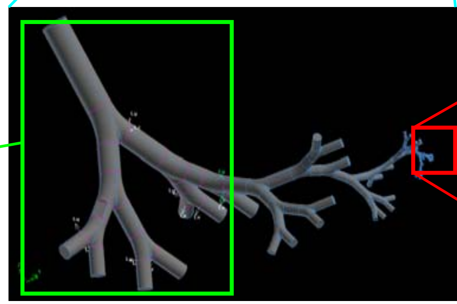


Alveoli Drug Delivery Model

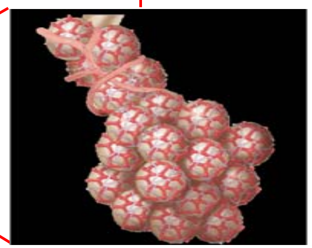
Local Drug Delivery Model



CFD Simulation of Pulmonary Block

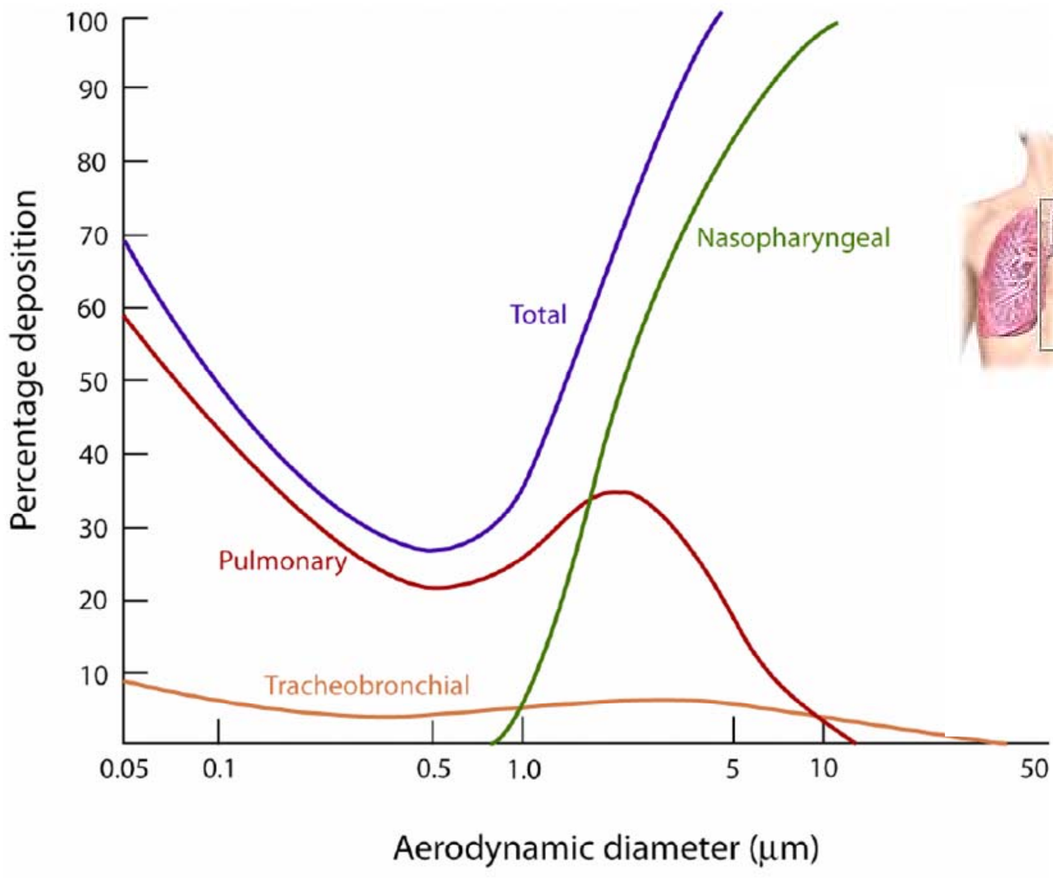


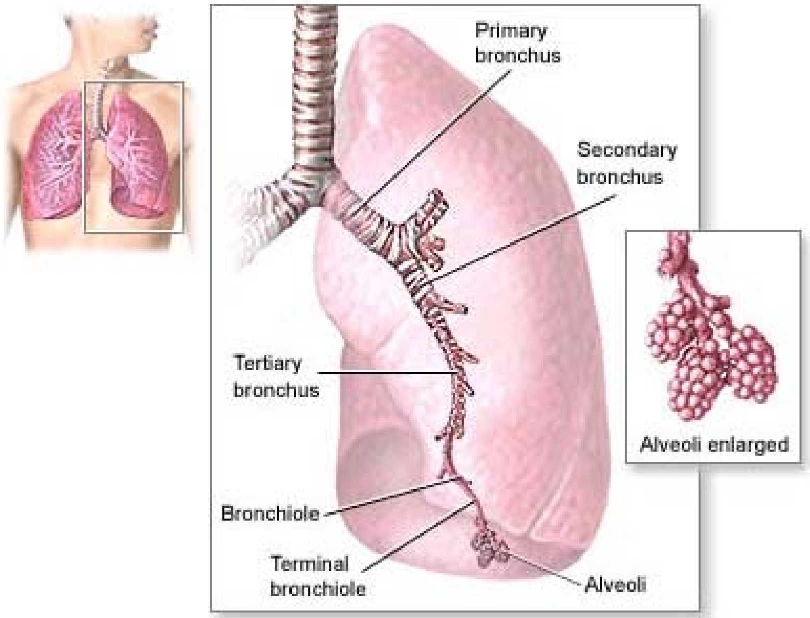
Multi-block Pulmonary Model



Alveoli Model

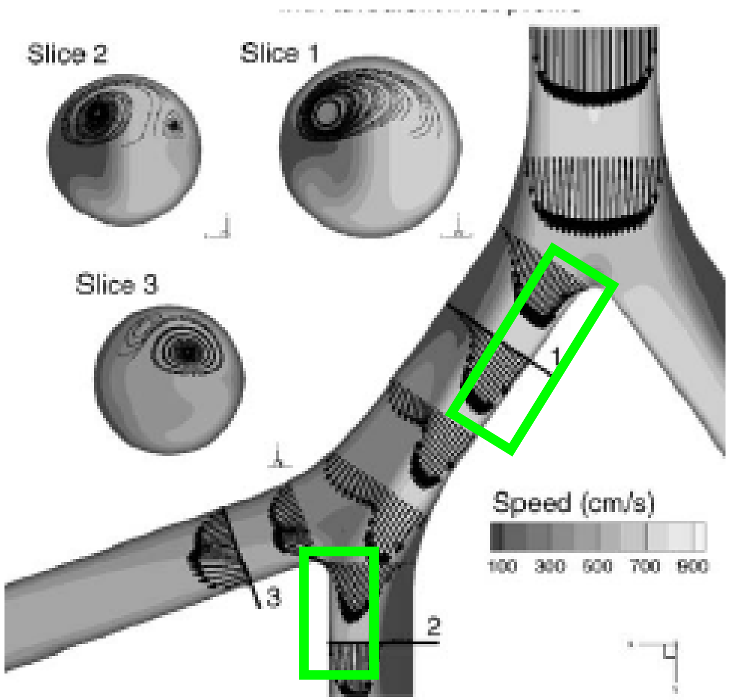
Fractional Deposition of Inhaled Particles

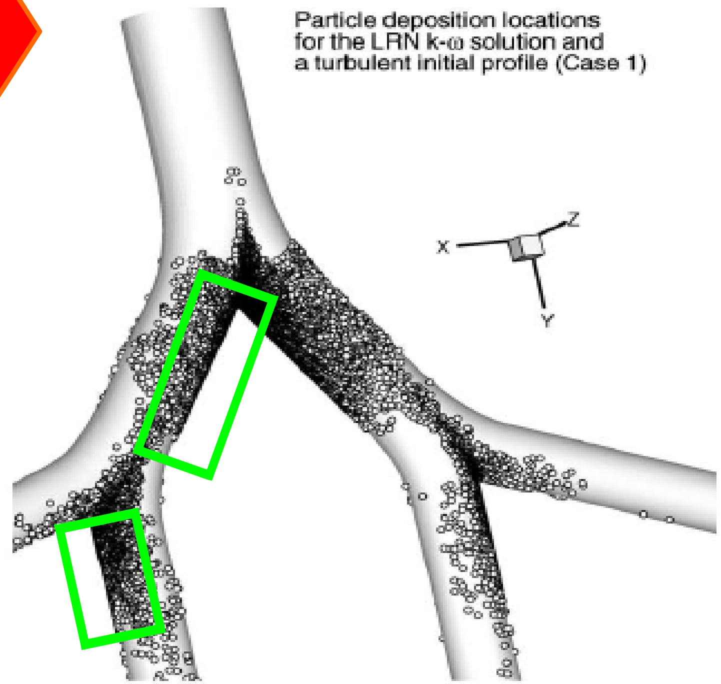




Fractional deposition of inhaled particles.

CFD Simulation of Inhaled Particle Deposition





CFD Simulation of inhaled particle deposition

Future R&D Directions of NMP Programme

2.6 Nanotechnology Applications for Selective Industrial Sectors

2.6.1 Information and Communication Technologies

2.6.2 Life Sciences and Health Care

2.6.3 Energy: Conversion, Storage and Efficient Use

2.6.4 Micro- and Nanomanufacturing Systems

2.6.5 Fibers, Fabrics and Textiles

2.6.6 Environment (Air, Water and Soil)

2.6.7 Chemicals, Consumer and Household Goods

2.6.8 Food & Agro-Biotechnology

2.6.9 Construction and Housing

2.6.10 Transport: Aircraft and Automotives

2.6.11 Defense and Security

Nanotechnology Applications for Selective Industries

- Information and Communication Technologies
- Life Sciences and Health Care
- Energy: Conversion, Storage and Efficient Use
- Micro- and Nanomanufacturing Systems
- Fibers, Fabrics and Textiles
- Environment (Air, Water and Soil)
- Chemicals, Consumer and Household Goods
- Food & Agro-Biotechnology
- Construction and Housing
- Transport: Aircraft and Automotives
- Defense and Security

Life Sciences and Health Care

"Lead Market" / Sector	Key R&D Targets	Technological Advancements	Applications & Time Frame	Relevant Industrial Sectors	Framework Actions
NanoMedicine – Diagnostics Theme 1	• Breakthrough improvements of factors 10 -1000 in diagnosis of major diseases	• Molecular imaging agents, new in vivo imaging and in –vitro detection mechanisms, lab-on-a-chip based, integrated IVD devices • Highly selective and sensitive imaging process	• Early diagnosis of the major diseases such as cardiovascular, cancer, auto immune, neurodegenerative and infectious disease • Markets Euro 5-10 bn, 5- 10 years		• Regulations • IPR agreements • Societal acceptance as anything "nano" • Reimbursement policy
NanoMedicine – Diagnostics Theme 2	• Construction of nano size structures used for combined imaging and therapy (drug release)	• Molecular imaging as a support and complement to therapy • Release of drug on the targeted site and/or monitoring of therapy by imaging	Combined diagnostics and therapy using unique nano size structures for both purposes		• Regulations • IPR agreements • Societal acceptance as anything "nano" • Reimbursement policy
NanoMedicine - Nanopharmaceutics Theme 1	• Construction of therapeutic nanoparticles (containing drugs especially macromolecular drugs : Biologicals, Foldamers and Nucleics)	• Packaging high concentrations of macromolecular and other drugs in suitable vectors for in vivo delivery.	• Major diseases. • Greener drugs • Market size • From current €10bn to ~€100bn, 5-10 years		• Regulations • IPR agreements • Societal acceptance as anything "nano" • Reimbursement policy
NanoMedicine - Nanopharmaceutics Theme 2	• Understanding & engineering • Nanoparticle transport in mammalian systems. • Targeting • Immunogenicity & tolerance	• Non-parenteral delivery • Intracellular/transcellular transport. • Oral, Nasal, (Blood Brain Barrier) and other delivery. • Understanding of EPR	• Increasing the market share of Biopharm's. • Greener drugs • Market size from current €10bn to ~ €100bn, 5-10years		• Safety and toxicology within a regulated environment • Reimbursement

Life Sciences and Health Care

"Lead Market" / Sector	Key R&D Targets	Technological Advancements	Applications & Time Frame	Relevant Industrial Sectors	Framework Actions
Nanomedicine Nanopharmaceuticals Theme 3 shared with other groups	• Predicting self assembling systems • Molecular recognition	• Hardware/software • Lack of networking / competition / industrial contact	• Market massive • Many applications also animal use reduction • 10+years		• Bringing science • Pharma • Software and hardware together
NanoMedicine - Regenerative Medicine **Using stem cell based therapies, regenerative small molecule / protein based drugs and scaffolding techniques to restore function to failing organs**	• Small molecule / protein based regulation of Stem cell differentiation • Robust and safe feeder systems for stem cell differentiation & survival • Biomaterial construction to provide architecture suitable for stem cell seeding and guiding in situ tissue regeneration.	• Stem cell differentiation • Tolerance – Rejection of Allogenic graft tissue • Unregulated differentiation of stem cells • Reliable in-vitro / in-vivo modelling systems • Robust manufacturing systems – purity, identity, potency and batch reproducibility	• Neurodegenerative disease: - treatment of Stroke (€62bn), Parkinson’s Disease(€23bn), Spinal cord injury (€37bn)and Multiple Sclerosis (€??bn), 10 years • Cardiovascular disease: replacing cardiomyocytes in the treatment of heart failure (€50bn), 10 years • Diabetes: insulin producing pancreatic cell formation (€125bn), 10 years		• Regulations • IPR agreements • Societal acceptance
NanoMedicine - Regenerative Medicine Theme 2	• R&D target: Development of stem cell screening assays to confer more predictable information about the safety and efficacy of new therapeutics		• Stem cell screening assays in predicting safety profiles of therapeutics. Market size small		
Nano facilitated drug discovery	• High throughput assays to quantify protein-protein interactions	• Existing assays not ideal for this new drug target	• Facilitating technology impacting NCE discovery/ commercial value moderate,5 years		• Very few
Anti-infective surfaces	• Safer hospital and home environments	• Current surfaces are often less safe than older ones	• Potential spread into many every day objects		• Nano acceptance

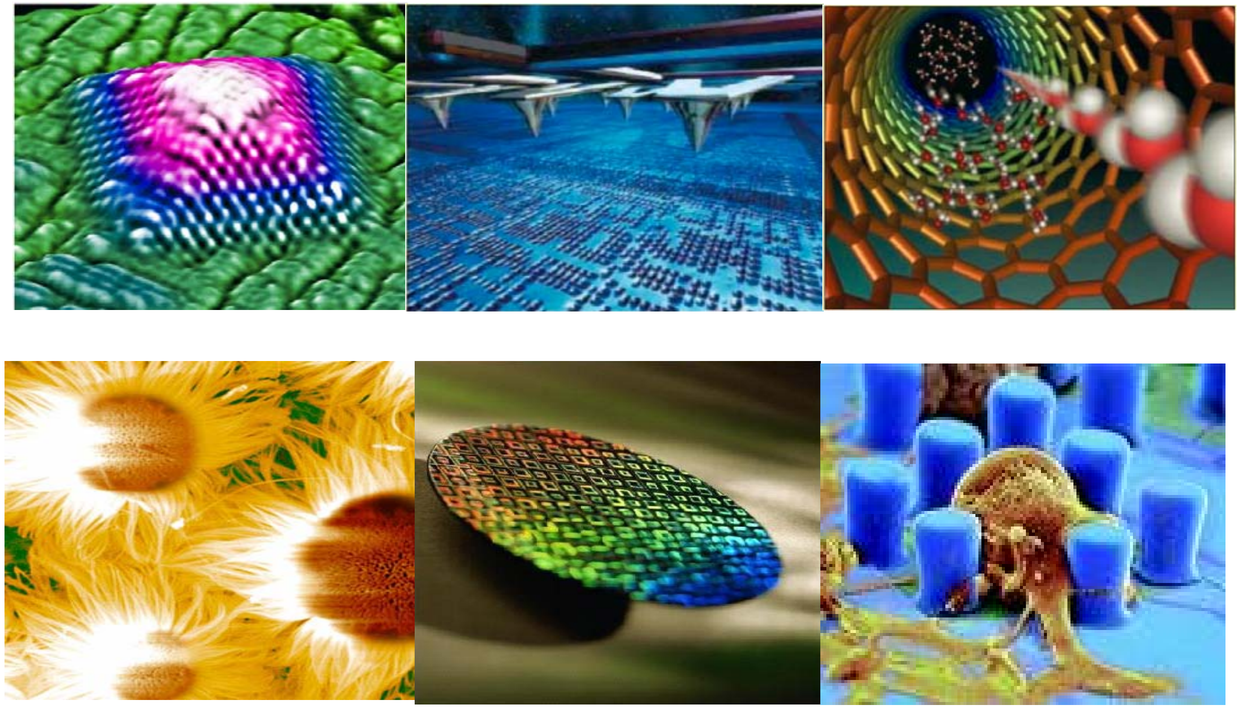
Energy: Conversion, Storage and Efficient Use

"Lead Market" / Sector	Key R&D Targets	Technological Advancements	Applications & Time Frame	Relevant Industrial Sectors	Framework Actions
Energy	• PV cell and modules energy efficiency improvement (1% improvement bring 5-7 % cost reduction), higher stability and lifetime • 70% efficiency of solar thermal collector	• Wafer Si PV modules based on new Si feedstock (low defect, improved crystal growth, etc.) • Polycristalline thin film (epitaxial growth and germination control, defect density) • Thin films technologies (optical confinement, light trapping, plasmonic, nanocrystalline, interfaces) • Understanding of defects, impurities, metastabilies, interface, layer structures • Understanding of organic material behaviour for new generation PV cells • Improve or new encapsulation approaches • Advance concentrator concept • Advanced nanosurfaces engineering for solar thermal collector • Better efficiency of solar thermal collector with new nanomaterial and nanosurface treatment	• Improvement based on today Si, 2-5 years • New Si based materials and concepts, 10 years • Prof of concept for modified deposition of thin film, 5 years • Implementation of advanced concepts of management of solar spectrum tailoring in ultra thin solar cells	• Environment	• Nanoscale characterisation • Integral simulation integrating both optical and electrical competencies • Standarization • Life cycle analysis • Integration in building
Energy	• Fuel cells	• Optimized electrodes, membranes, electrolytes • Better understanding and efficiency of the catalytic system (reduce noble material use, development of advanced alloys) • Development of ceramic nanopowder for SOFC • Membrane based on organic inorganic nanocomposites • Functionalized polymers with nanotexturing • Electrode nano-structuring to improve oxygen/hydrogen conversion	• Micro fuel cells for mobiles applications • Automotive application • Transport (sailing, airplane, etc.) • Building applications (auxiliary power units)	• Environment	• Nanoscale characterisation and simulation • Standarization • Safety and security • Recyclability

Energy: Conversion, Storage and Efficient Use

"Lead Market" / Sector	Key R&D Targets	Technological Advancements	Applications & Time Frame	Relevant Industrial Sectors	Framework Actions
Energy	• Batteries and supercapacitors.	• Optimized electrode material and electrolytes • Anodes and cathodes with higher loading/discharge capacity based on nanomaterials • Higher energy densities • Introduction of nanomaterials for the separators, electrolytes, etc. • Improvement of life and temperature stability. • Nanotexturing, nanostructuring and architectures	• Batteries for hybrid electric vehicles HEV (>3years) and Electric vehicles • Thin film batteries for mobile electronic • Supercapacitors for mobile application, energy recovery	• Security • Environment	• Nanoscale characterisation and simulation • Standarization • Safety and security • Recyclability
Energy	• Thermoelectricity	• Improvement of efficiency through new generation of nanomaterials • New architectures based on nanostructuring, nanotexturing, nanolayering • New nanostructured semiconductors with optimized boundary layer design • Nanostructures analyzed in connection thermoelectica (quantum dots, super lattices, quantum wires, etc) • New process to allow production of such devices	• Components for car applications (>5-7years) • Human body application for intelligent textiles • Portable electronics.	• Environment	• Nanoscale characterisation and simulation • Standarization • Safety and security
Energy	• Biomass	• New conversion methods (catalyst, sensoric, etc) • Nano optimization of bio resources.	• Provision of fuel	• Environment	• Nanoscale characterisation • Safety and security

Introduction to NANO*futures* Vision



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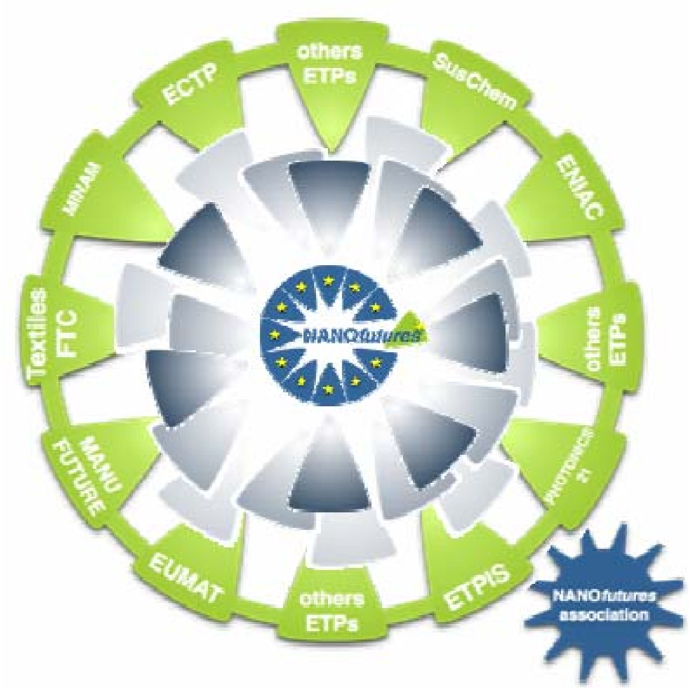
NANO*futures* Initiative

- The NANO*futures* platform would become a European multi-sectorial, cross-ETP, integrating platform with the objective of connecting and establishing cooperation and representation of all relevant Technology Platforms that require nanotechnologies in their industrial sector and products.
- NANO*futures* and its operative branch NANO*futures* association will act as a "Nano-Hub" by linking JTIs, associations, ETPs with expert groups in a collaborative environment.

NANO*futures*' Networking

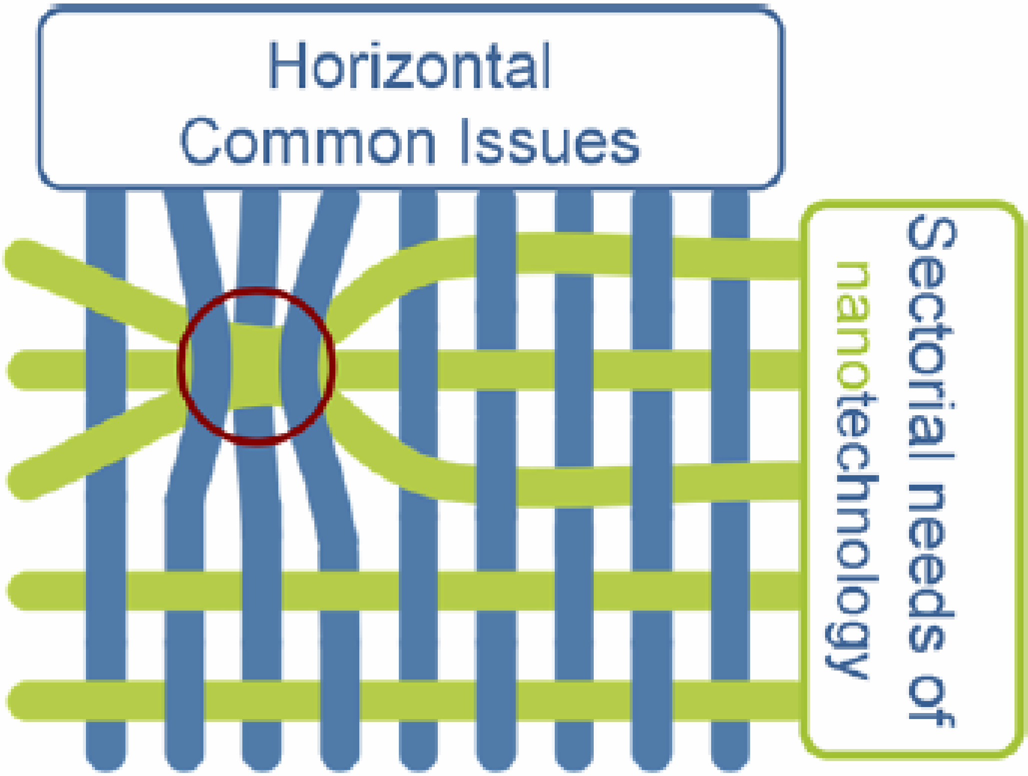


NANO*futures* Integrating Role

- NANO*futures* at its base will be open to industry, SMEs, NGOs, financial institution, research institution, universities and civil society with an involvement from Member States at national and regional level.
- It will be an environment where all these different entities would be able to interact and come out with a shared vision on nanotechnology futures.
- NANO*futures* collaborate with the ETPs on the basis of a Memorandum of Understanding.

NANO*futures*' integrating role

Schematic of NANO*futures* Approach



Horizontal Working Groups

- Working groups are organized under the 3 main topic areas addressed by NANO*futures*: “technology”, “regulation and standards” and “innovation”.
- Ad hoc Groups can be constituted by the Steering Committee.
- Objectives of the horizontal working groups would be to present recommendations for strategic actions under each of these three main topics:

Research and development to promote nanotechnology (“technology”), including:

- ✓ Tools / equipment / measurement technology
- ✓ Infrastructure development
- ✓ Nanomaterials
- ✓ Nanostructuring
- ✓ Bottom-up manufacturing

Regulatory and standardization provisions for nanotechnology (“regulations and standards”), including:

- ✓ Safety
- ✓ Quality
- ✓ Performance

Decisional Structure

- Chair and two Co-chairs of the organization are elected by the Steering Committee
- Steering Committee
- National Platform Representatives Board

Membership and Participants

- Members are the ETPs representatives and representatives for any other groups or clusters identified of importance and not directly represented by any ETP.
- Participants to the working groups and other NANOfutures activities may be coming from the platforms and groups or on an individual basis as required.