NEW MATERIALS

Trends, Roadmaps & Potential FP7 Call Topics

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in the FP7 Cooperation Programme

‘NEW MATERIALS’

is part of

Nanosciences, Nanotechnologies, Materials and New production Technologies (NMP)

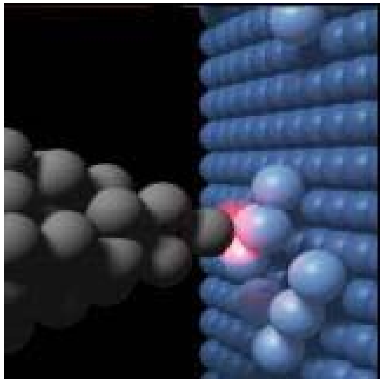
Developments in **'NEW MATERIALS'**

Three major trends:

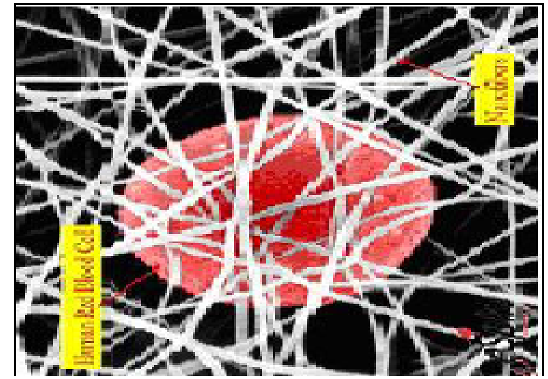
1) Growing importance of
Nanosciences and Nanotechnologies

2) Convergence of technologies from various discipline areas
e.g. *nano-bio, nano-neuro, nano-bio-neuro-cogno*, etc.

3) Virtual (*i.e. computer based*) design & production



Why nano?



From the material point of the view, small dimensions give new opportunities such as:

- **control at the nanoscale enables perfect, defect free structures, featuring exceptional properties for strength, conductivity etc.**
- **nanostructures and particles create a very large surface area, featuring unique surface activity for sensing, catalysis, absorption etc.**
- **completely new particles, unknown in nature, can be produced with new properties, such as carbon nanotubes**
- **at the nanoscale, quantum effects can be used to obtain new optical effects**

Example: Carbon Nanotube (CNT) reinforced fibers

With **carbon nanotubes** (diameter 1-2 nm, aspect ratio 103,104) the following ultimate material properties are foreseen:

- mechanical: E-modulus 1-5 MPa, ultimate tensile strength: 30-180 GPa
- electrical conductivity: 6000 S/cm, thermal conductivity: 2000 W/mK
- ultrahigh surface area: 1500 m2/gram

Up to now, the exceptional tensile strength properties have not been realized yet, at present only 1-2 percent of the potential strength has been realized.

- **Space elevator project (USA):**

60% CNT filled polymer (PMMA or PS) with an exceptional tensile strength of 60 GPa.

Current status for these composites is 2-4 GPa.

Example: **Nano(clay)platelets reinforced materials**

Nanoplatelets (thickness 1-2 nm, aspect ratio 10^2-10^3) are relatively low cost nanoadditives (5-10 €/kg) and are being applied in order to:

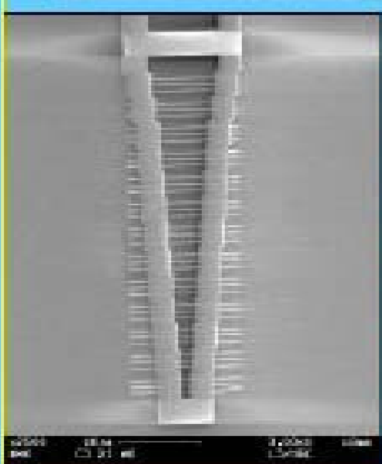
- *increase chemical, UV and thermal stability (50 to 100 K up)*
- *increase fracture toughness: typically a factor 3*
- *increase tensile strength: factor 2*
- *diffusion barrier: factor 2-10*

Nanoplatelets: graphite (GNP), nanoclay; exfoliated nanoclay platelets

Nanomechanical Oscillators

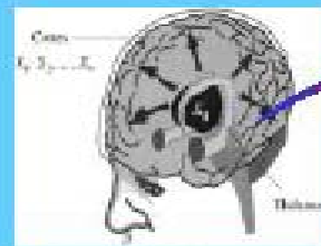
Dr. Brian H. Houston

Compact Ultralow Power Electronics

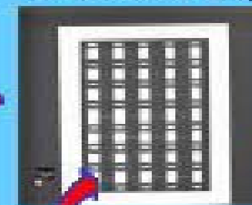


- Electromechanical oscillators will enable the next major leap in integration and thus size reduction.
- Much lower power communication and signal processing equipment (e.g. radios, etc.)
- Saving the warfighter significant battery weight and space.
- Device shown is fabricated from NRL diamond films.

Artificial Brains for Intelligent Autonomous Vehicles



Nanoresonator array



"nano" DIAMOND resonator

- Coupled arrays of oscillators will be used instead of neurons.
- ~ 1 billion nanoresonators
- Artificial brains will surpass computers in many ways.
- Self-aware autonomous vehicles.

Compact Low Power Highly Sensitive Chem/Bio Detection

- A high performance resonator will be used to detect explosives as well as chemical and biological agents with sensitivity that is better than large conventional power-hungry systems. The intent is to provide small, low power sensing systems that are extremely portable.

The Nanomaterials Pathway to Better Batteries

Lightweight Power Sources for Autonomous Devices

Presenter: Karen Swider Lyons, Surface Chemistry Branch

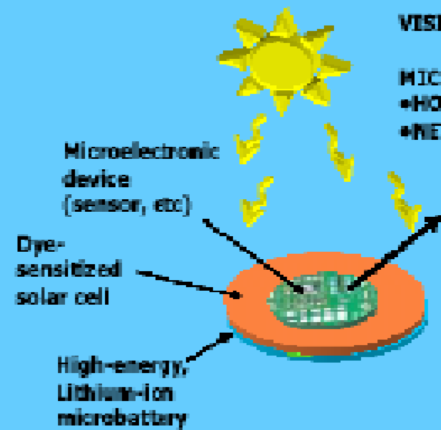
THE PROBLEM:
HIGH ENERGY BATTERIES NOT AVAILABLE FOR MICRODEVICES

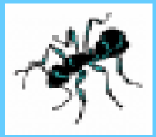
Watch Battery 5 to 10 µA

Smart Dust
K. Pister, Berkeley
DARPA/ETO MEMS Program

VISION: HIGH ENERGY BATTERY WITH ENERGY HARVESTING

MICROPOWER FOR AUTONOMOUS MICROSENSORS AND DEVICES
- **HOMELAND DEFENSE**
- **NETWORKED SENSORS FOR SHIPS**

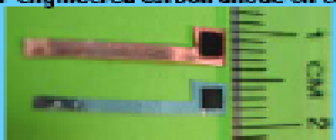




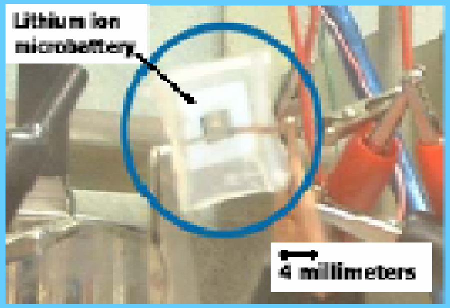
Battery harvests energy from microsolar cell - used to power microdevice

THE SOLUTION: PART 1
FABRICATE HIGH ENERGY LITHIUM MICROBATTERIES

Laser-engineered carbon anode on copper



Laser-engineered lithium cobalt oxide on aluminum



Specs on 1st generation packaged Li-ion microbattery
- 4.17 Volts
- 100 µAh

} Power for mircroelectronic devices

- +24 cycles
- ambient air

} Durable

THE SOLUTION: PART 2
MAKE ULTRA-LIGHTWEIGHT BATTERIES WITH NEW NANOMATERIALS

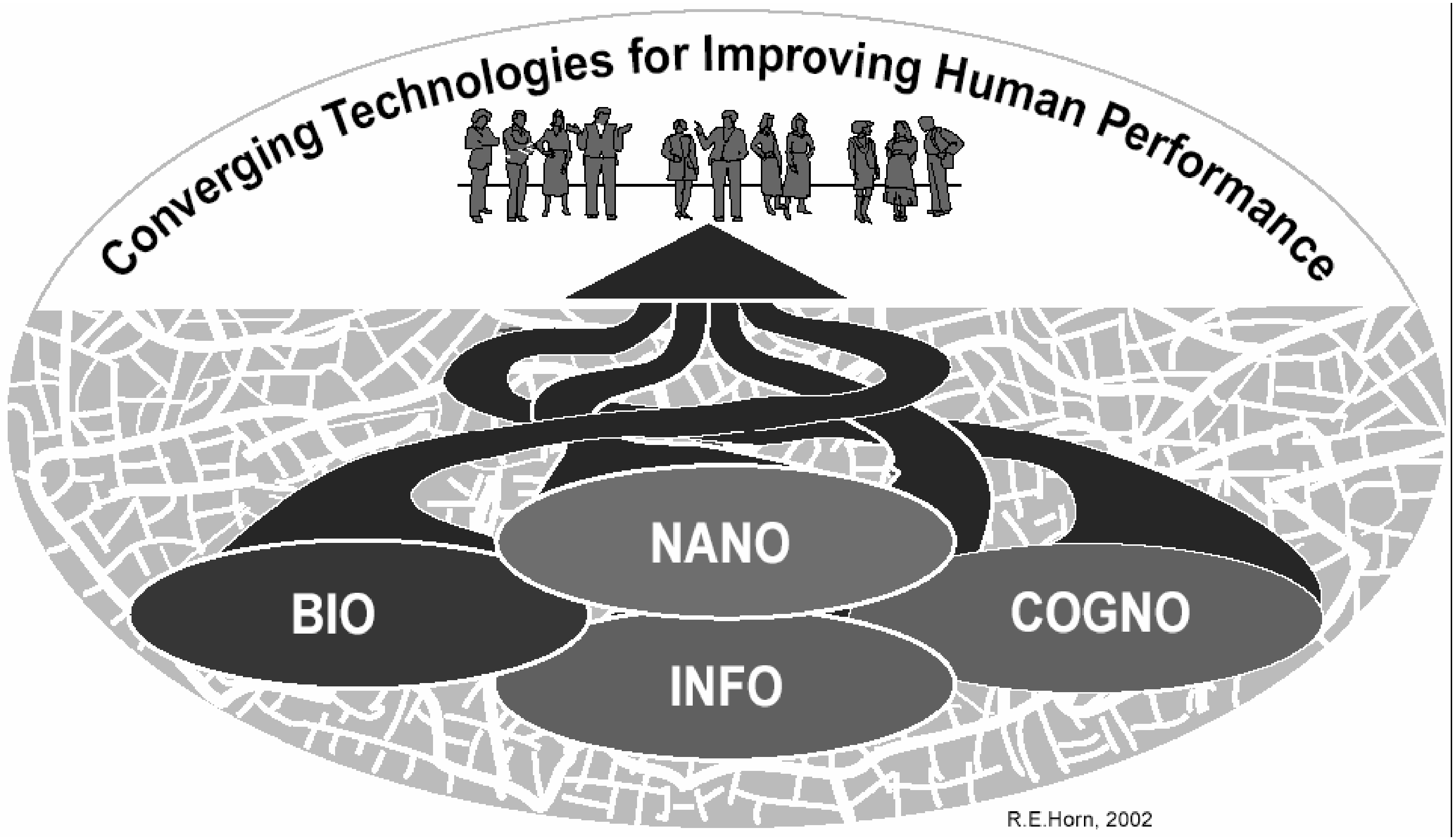
- Build nanostructured electrodes to improve interfacial contact and ionic conductivity
- RESULT: Extract more energy from the battery materials and lower the weight of the battery

Knowledge based materials and production technology:

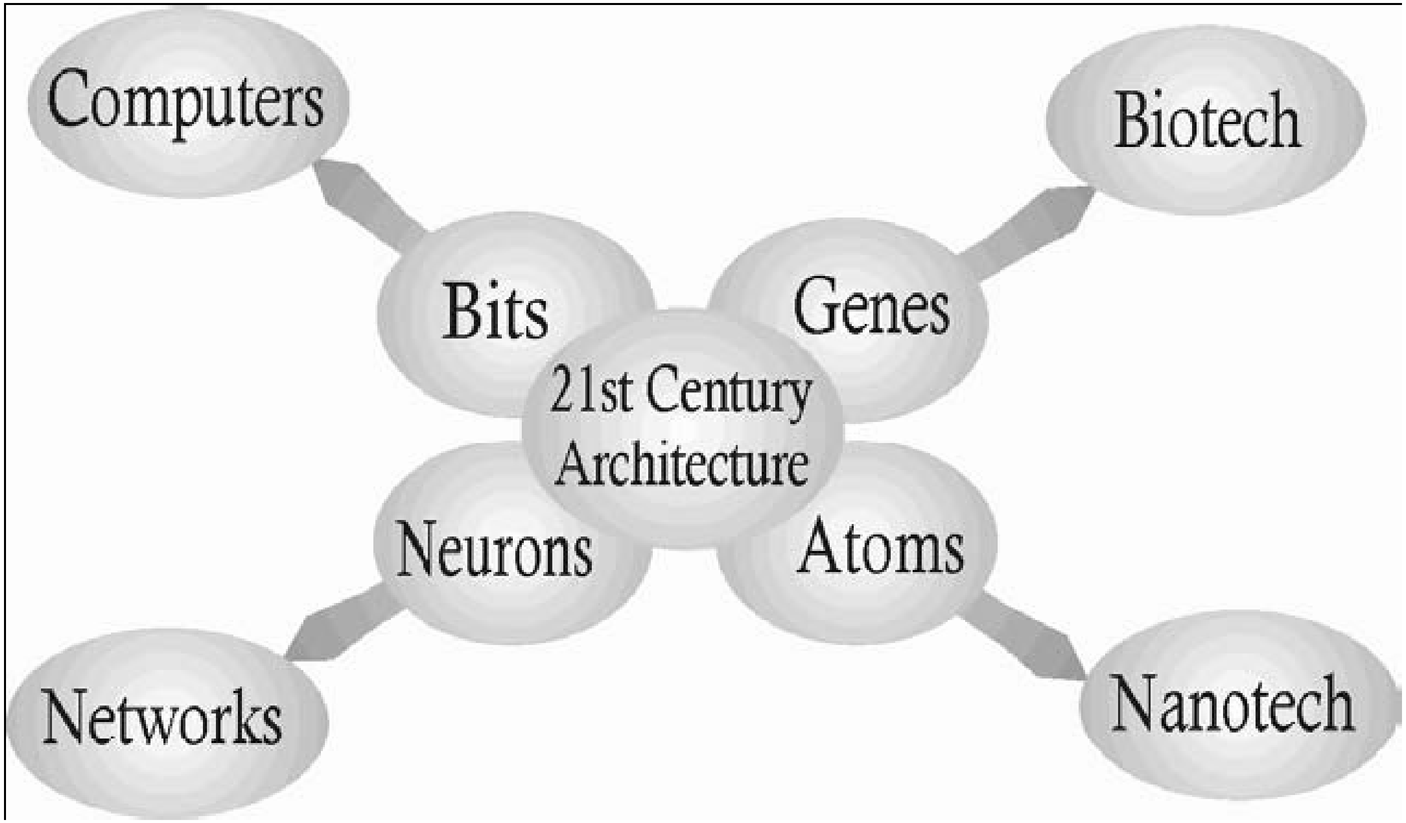
Hierarchy

	EC FP's
Integrative	< 2010
↑	
Converging	< 2005
↑	
Multidisciplinary	< 2000
↑	
Monodisciplinary	< 1990

Convergence of technologies



Convergence of technologies: building blocks and power tools



Source: **Converging Technologies for Improving Human Performance,** *NSF/DOC-sponsored report, USA 2002*

Convergence of technologies

Working in converging technology areas would especially benefit SME's, since this would enable many new – **cross-sectorial** – applications to enter the market quickly.

Examples:

- Self healing of damage caused by abrasion and wear
- Self adapting materials/sensors with variable strength or sensor properties
- smart multi-tasking targeted systems for joint diagnosis and therapy ("theranostics")

Virtual (*i.e. computer based*) design & production

‘Digital mock-up’:

- **Cost savings**
- **Customisation**
- **Faster development time**
- **....**

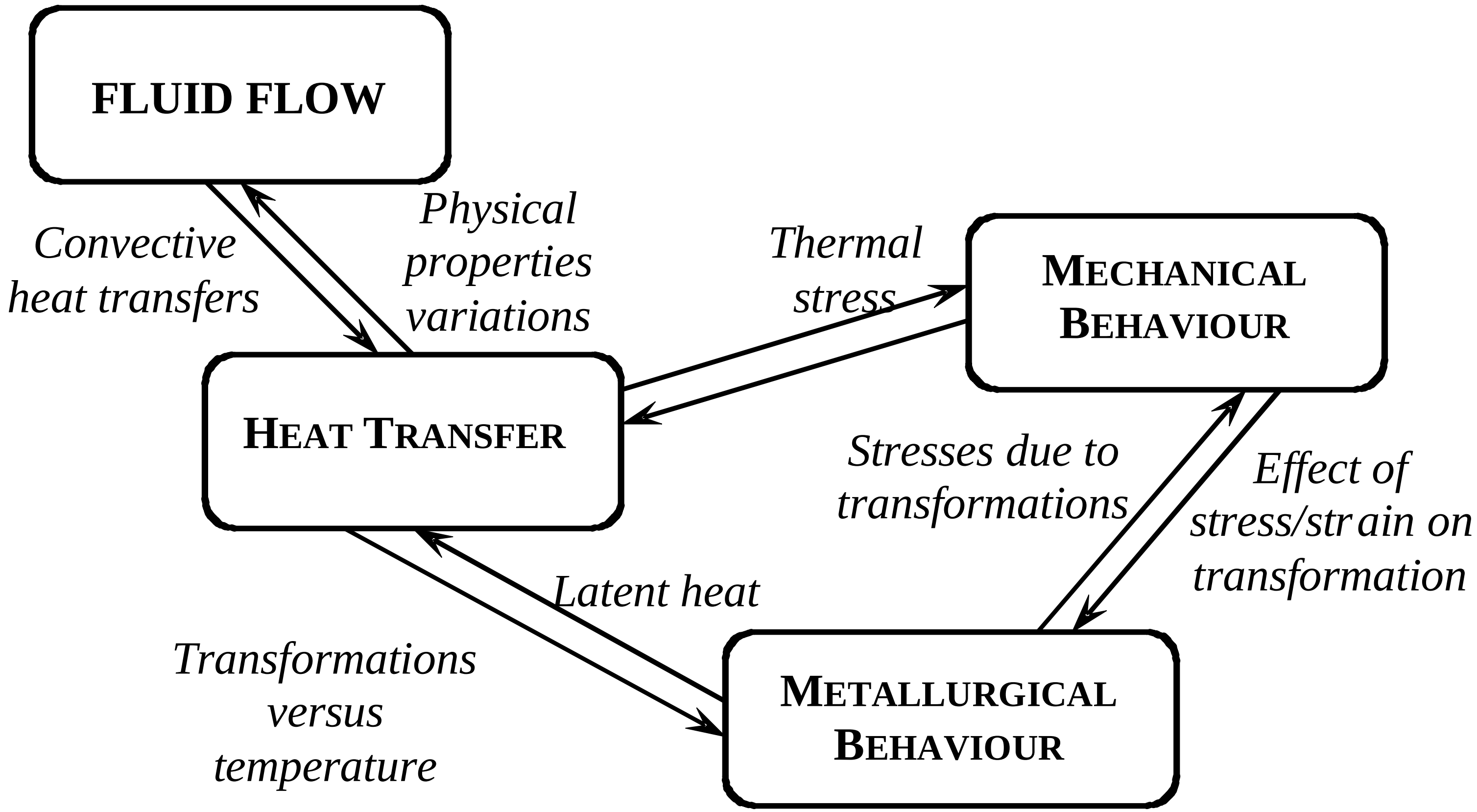
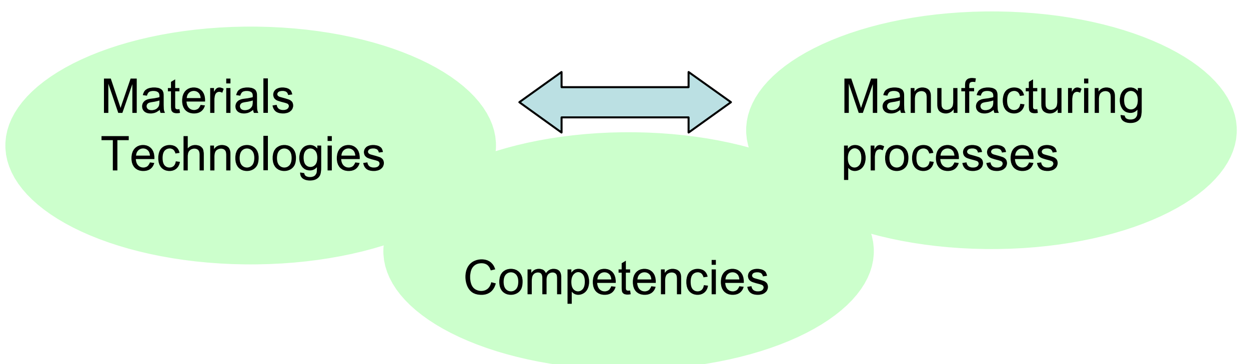


Figure 1 - Thermal, metallurgical and mechanical couplings in gas quenching

Roadmaps in New Materials

Various roadmaps all agree that there should be a focus on:

- Sustainability in production and products
- Multi-disciplinary collaboration
- Concurrent engineering:



FP7 expected Call 1 topics NMP Programme

A Nanosciences and Nanotechnologies

B Materials *B1 Mastering nano-scale complexity*
B2 Knowledge-based smart materials with tailored properties
B3 Novel biomaterials & bioinspired materials
B4 Advances in chemical technologies & materials processing
B5 Engineering for high-performance knowledge-based materials

C New Production Technologies

D Integration of NMP technologies for industrial applications

C New Production Technologies

C1 Development & validation of new industrial models & strategies

C2 Adaptive production systems

C3 Networked production

C4 Rapid transfer & integration of new technologies into the design and operation of manufacturing processes

C5 Exploitation of the convergence of technologies

D Integration of NMP technologies for industrial applications

directed towards various sectors: bio(medical), transport, building and integration into ERA-NET programs

FP7 Call 1

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