Bayer MaterialScience

Bayer's responsible approach to Nano based innovations

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Bayer Working Group Nanotechnology

Milano, 02. December 2010

Working Group Nanotechnology

Driving forces for Innovation: Technology challenges of the society

- **Environment/Climate**
- **Resources**
- **CO_2-Prevention**
- **Energy:**
  - **Conversion**
  - **Storage**
  - **Saving**
  - **Transport**
- **Mobility**
- **Health Care**
- **Nutrition**
- **Security**
- **Information/ Communication**

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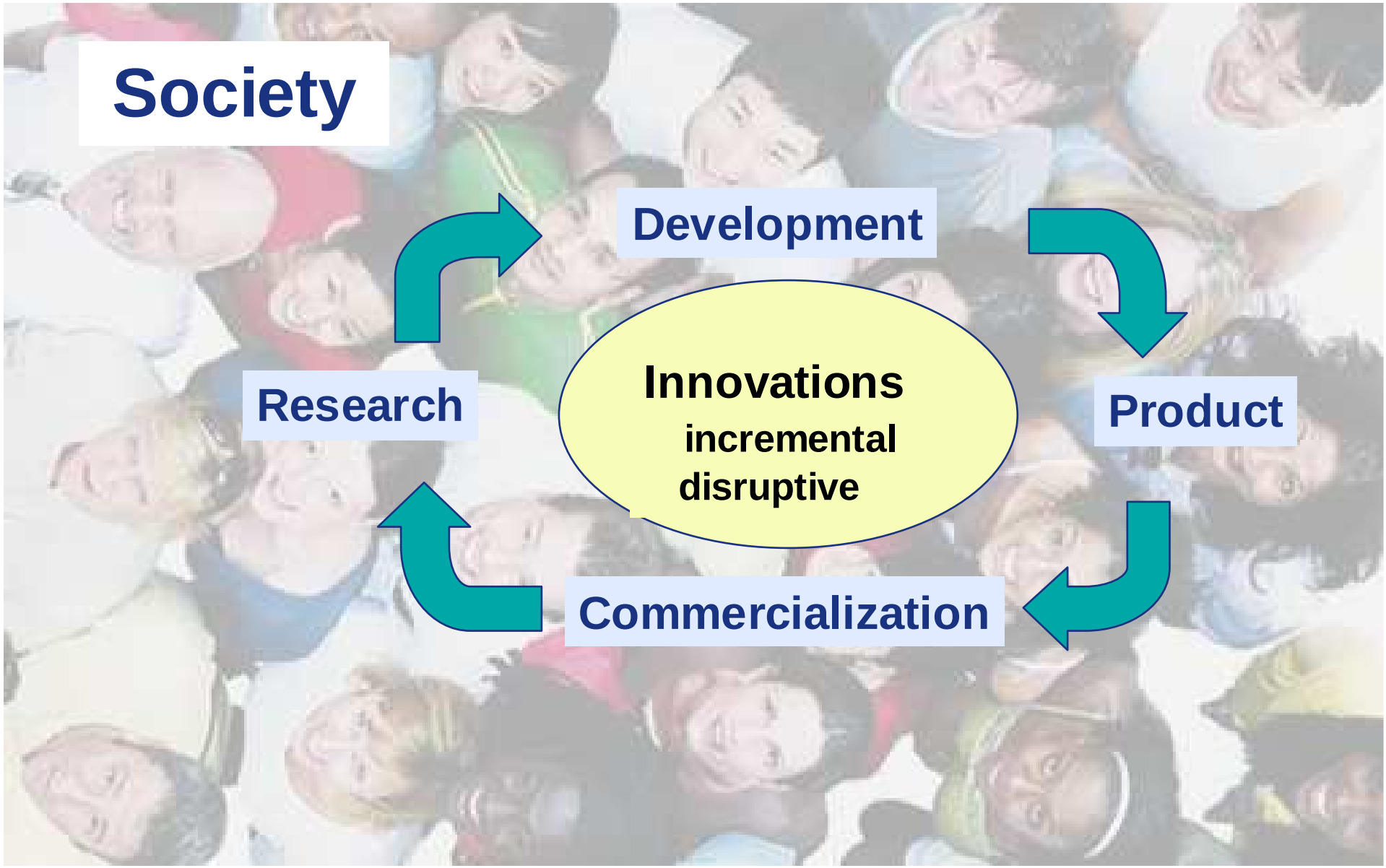
Innovation is consisting of: Research, Development and Viable Commercialization:

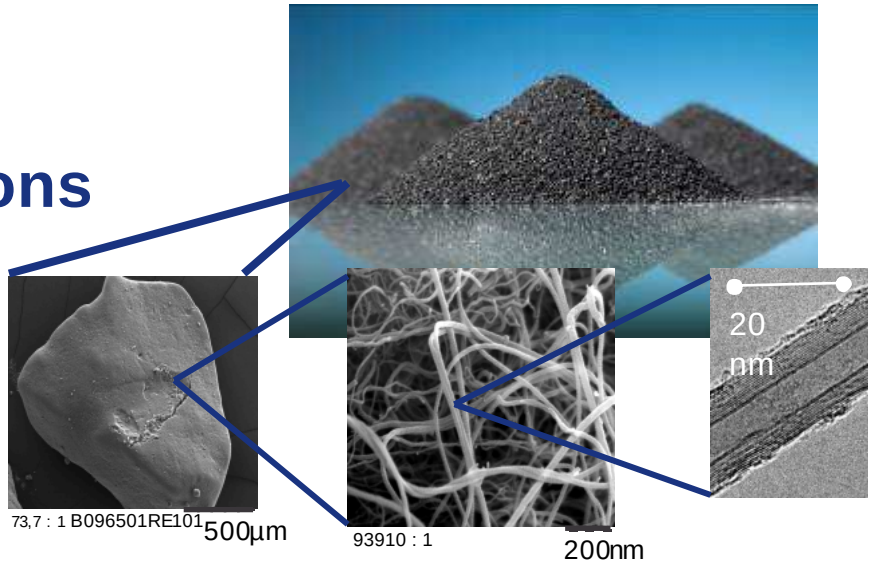


Approaches to address technology related challenges and needs in the society

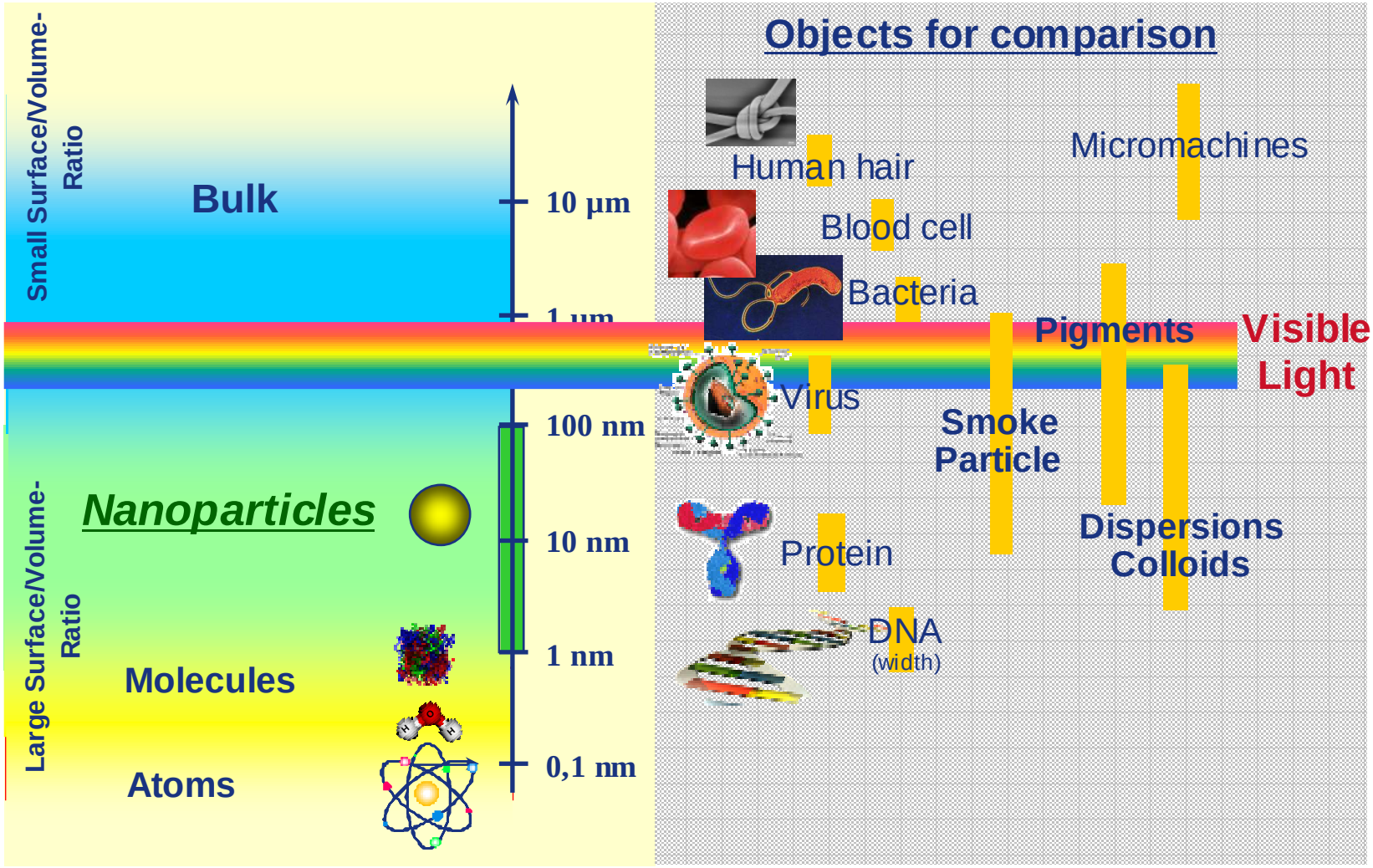
- **Optimized use and combination of existing established technical solutions**
  - **Solar Impulse** (B. Piccard - www.solarimpulse.com)
    Once around the world in a manned airplane powered only by solar energy.
    Need for efficient energy
    - Conversion (photovoltaic),
    - Storage (battery),
    - use (light weight)

- **Develop new technology options for relevant applications**
  - **Nanotechnologies**
    - Materials technology

Nanomaterials

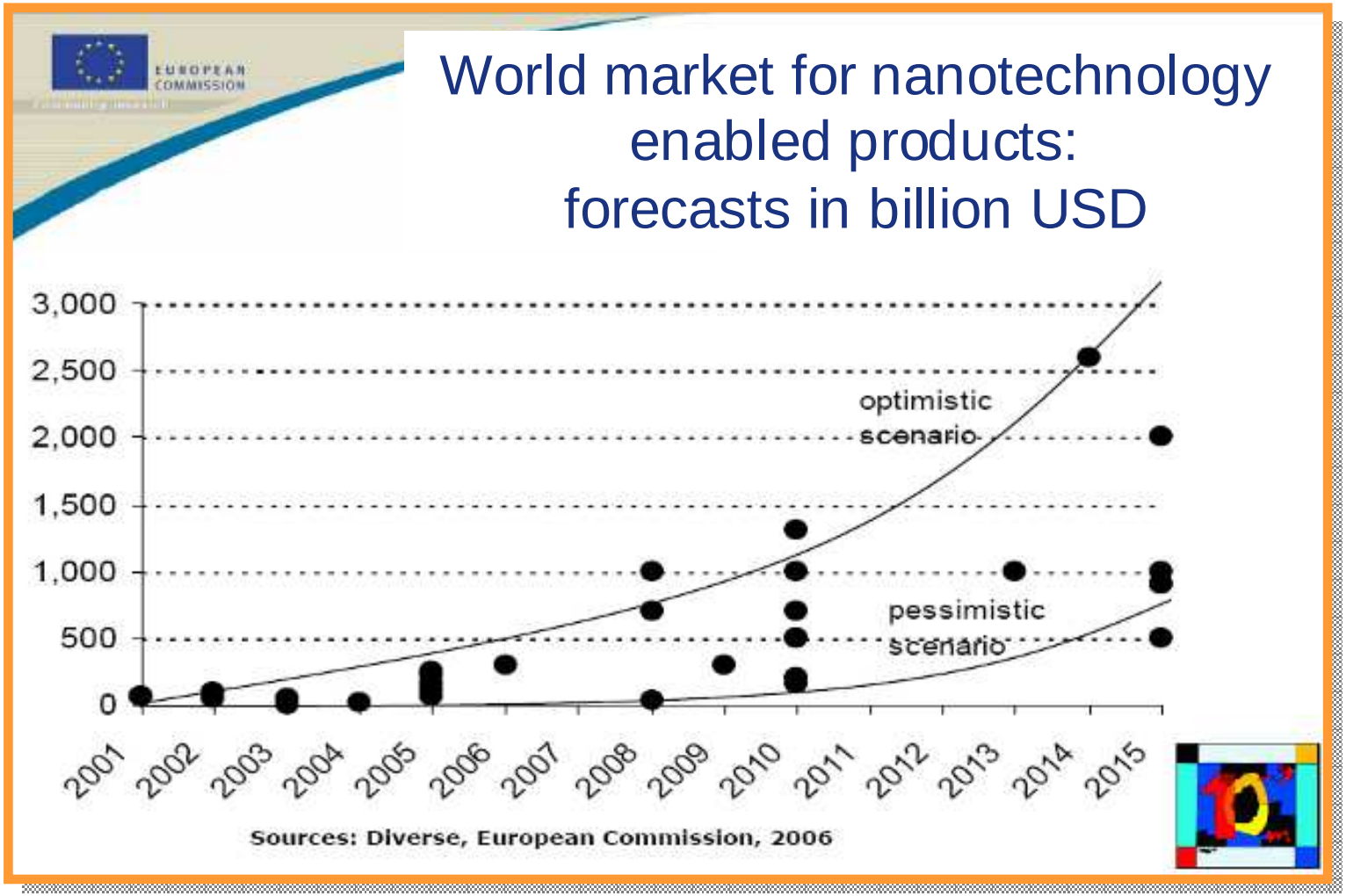


Nanoscale and Nanotechnology



Nanotech: purposeful tool or process to engineer matter on a scale between appr. 1 and 100 nm, to achieve modified or new sized dependent properties

The Economic Visions on Nanotechnolgy: Markets for Nano-based Value-Chains



Renzo Tomellini,
DG Research / Lux Research

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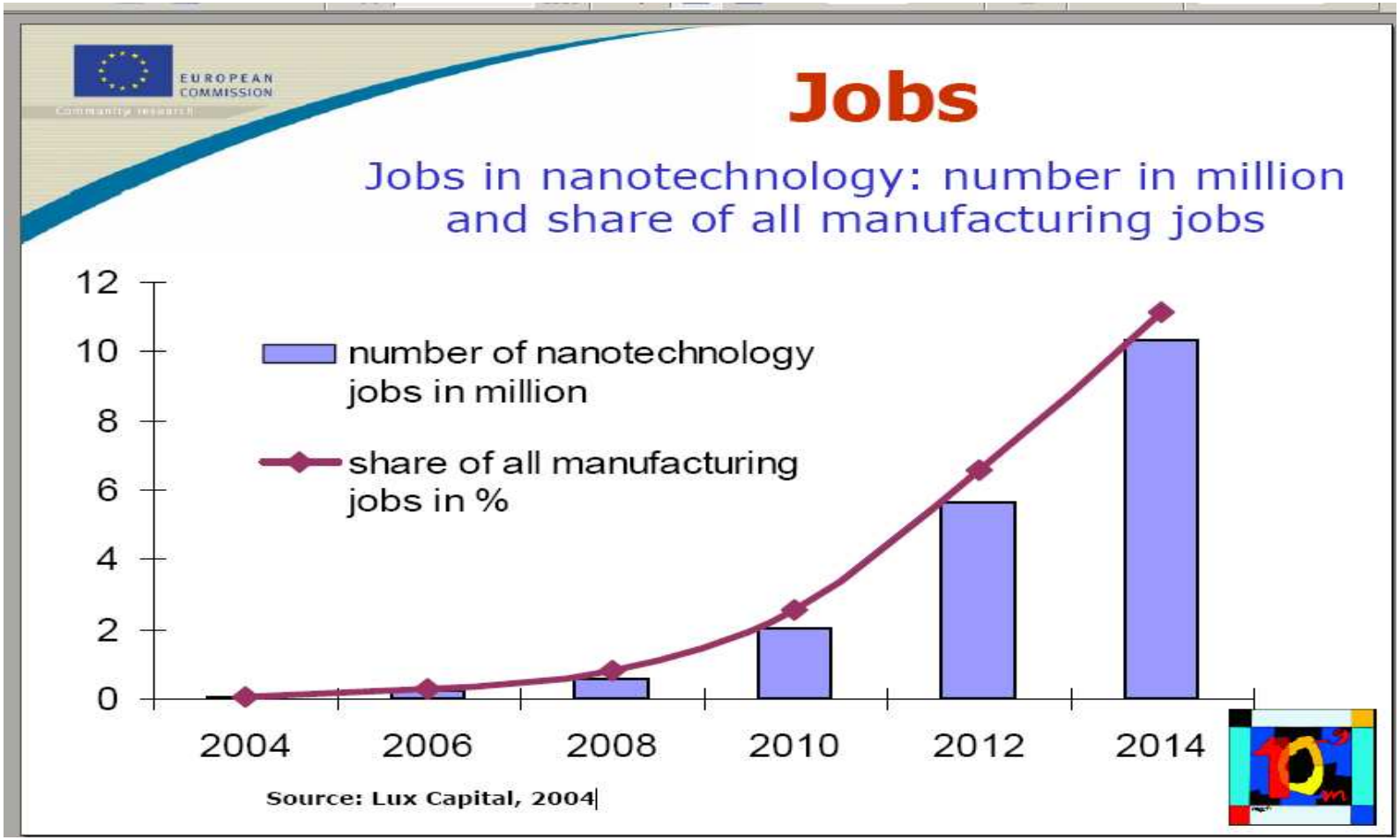
The Economic Visions on Nanotech: Jobs



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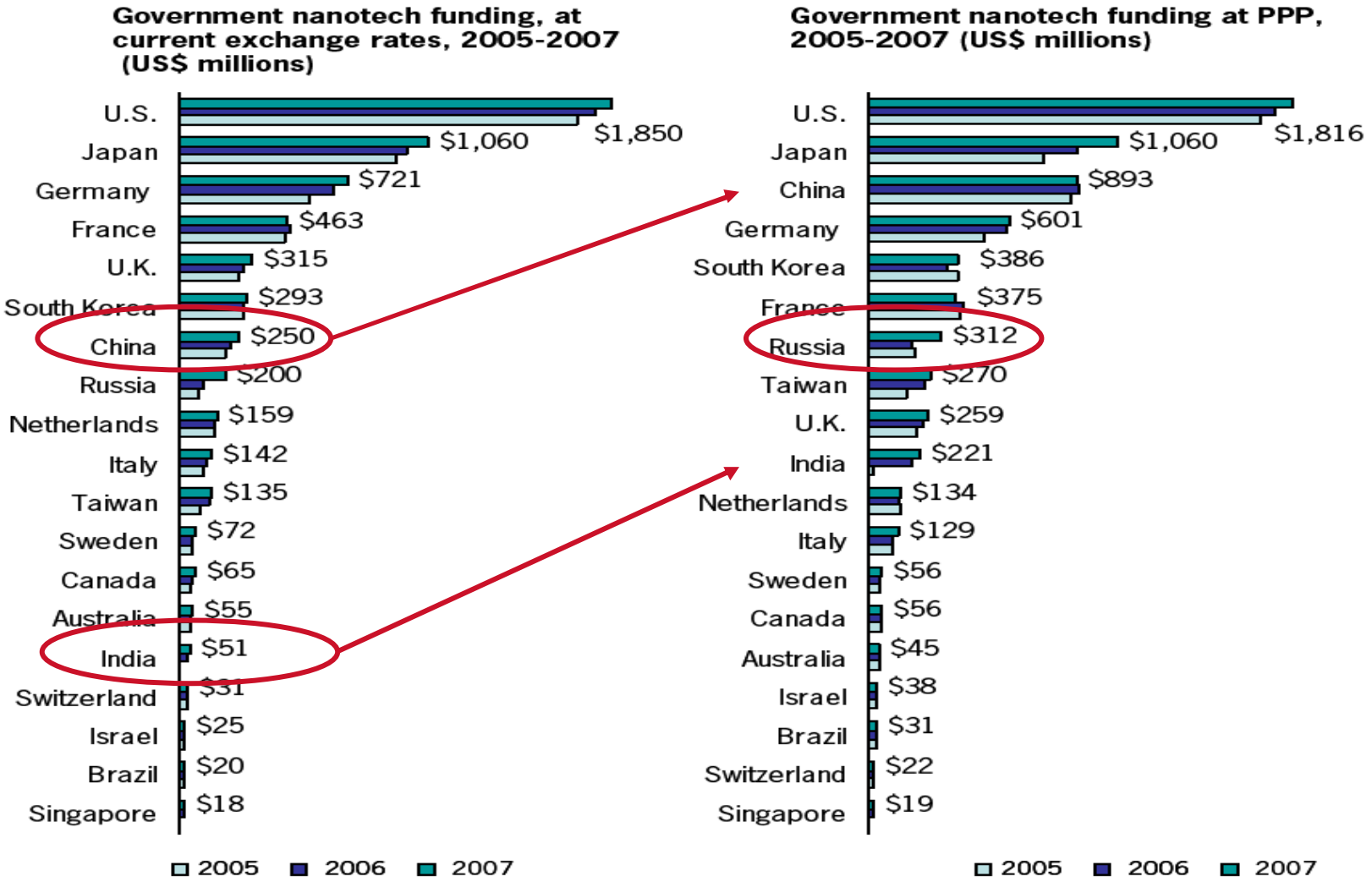
Government Nanotech Funding 2005-2007
Developing Countries are catching up



Source: Lux Research

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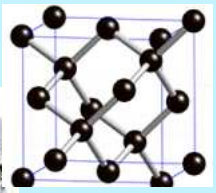
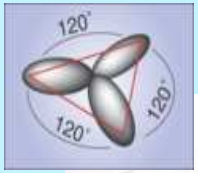
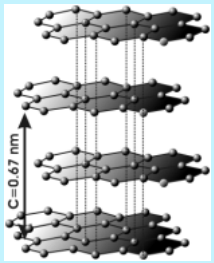
Carbon Structures

Diamond

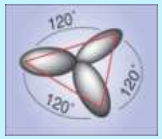



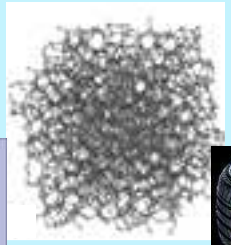
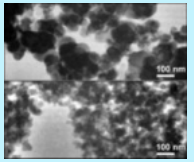
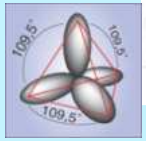
Graphite



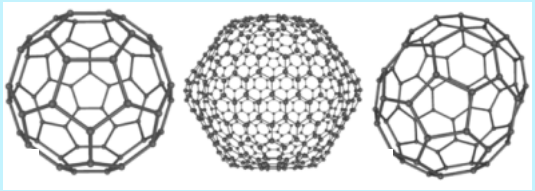



Amorphous carbon

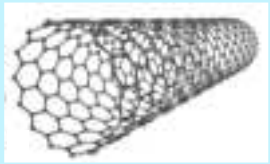
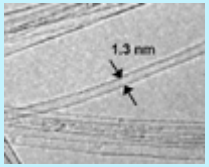


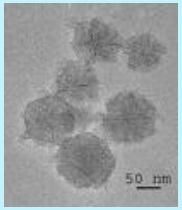
Buckminster Fullerenes



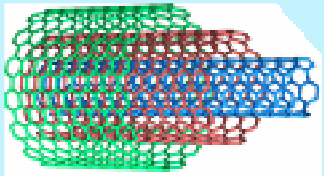
Single Wall Carbon Nanotubes

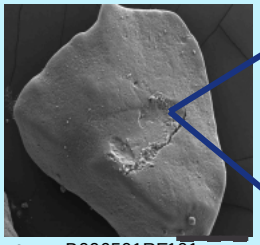



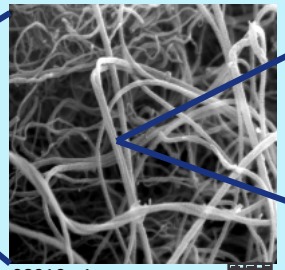
Carbon nanohorns

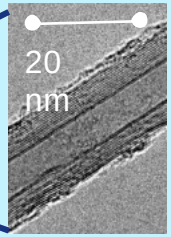



Multi Wall Carbon Nanotubes Baytubes®





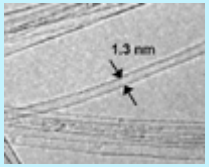




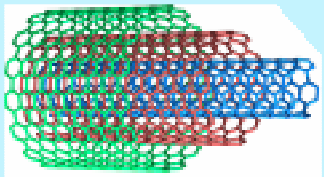
Carbon Structures

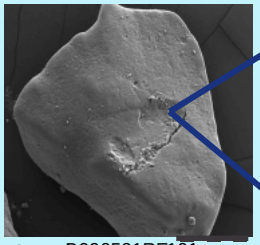
Carbon Nanotubes – posses superior
- Electrical conductivity
- Mechanical strength
- Heat conductivity
- Chemical resistivity
and
- Low macroscopic density
- High surface area

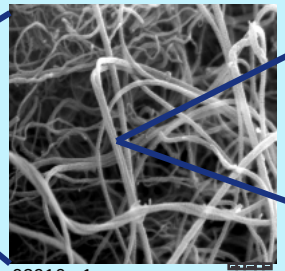
Single Wall Carbon Nanotubes

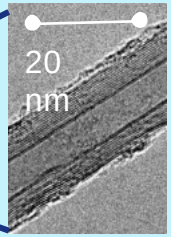


Multi Wall Carbon Nanotubes
Baytubes®









Carbon nanotubes - on industrial scale

Commercialization requirements:

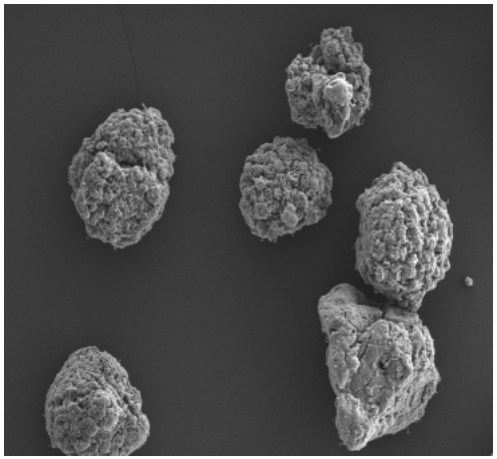
- Cost-effective manufacturing process
- High product purity even without post-purification
- Reproducible quality
- Reliable supply situation (incl. HSE)

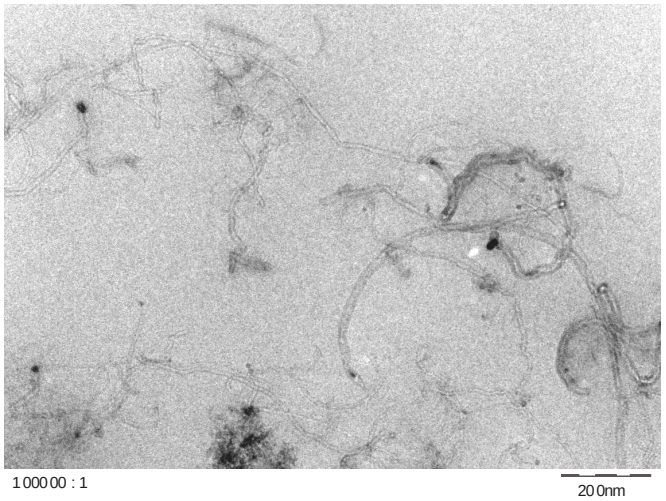
Status:

- Estimated world wide production capacities for SWCNT in the range of few t/y
- Announced existing world wide production capacities in 2010 in the range of ca. 800 – 1000 t/y
- Announced world wide MWCNT production capacities for 2012 in the range of ca. 1500 – 2000 t/y
- Main player for MWCNT: Arkema (F), Bayer MaterialSciences (D), CNano (US/C), Hyperion (US), Nanocyl (B)
- Target: Development of hybrid materials with extraordinary mechanical, electrical, thermal and physico-chemical properties

Ice hockey sticks from Montreal Sports Oy, Finland, made from an innovative composite material based on CNTs

CNT Dispersion is Key,
Challenge across the value chain:





CNT Architecture → Agglom. Structure → Surface Chemistry → Dispersion Technology → Stabilization

and

Commercial Viable Applications

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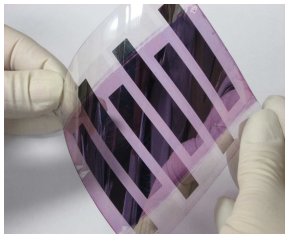
Potential use of CNTs for sustainable supply and use of energy in the future

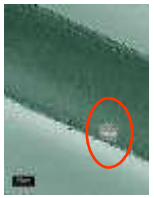
Energy - Conversion

Efficient use of wind energy (wind)
Efficient lighting/displays
Solar cells



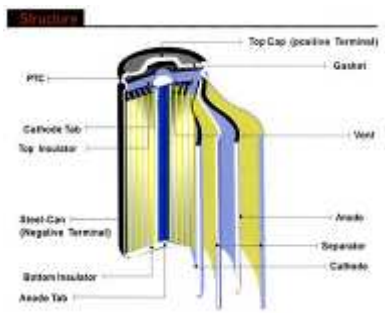
Energy - Transport

Efficient use of heat conductivity
-Under-floor heating
-Windshield defroster heating
Microwave antennas
Electrical circuits



Energy - Storage

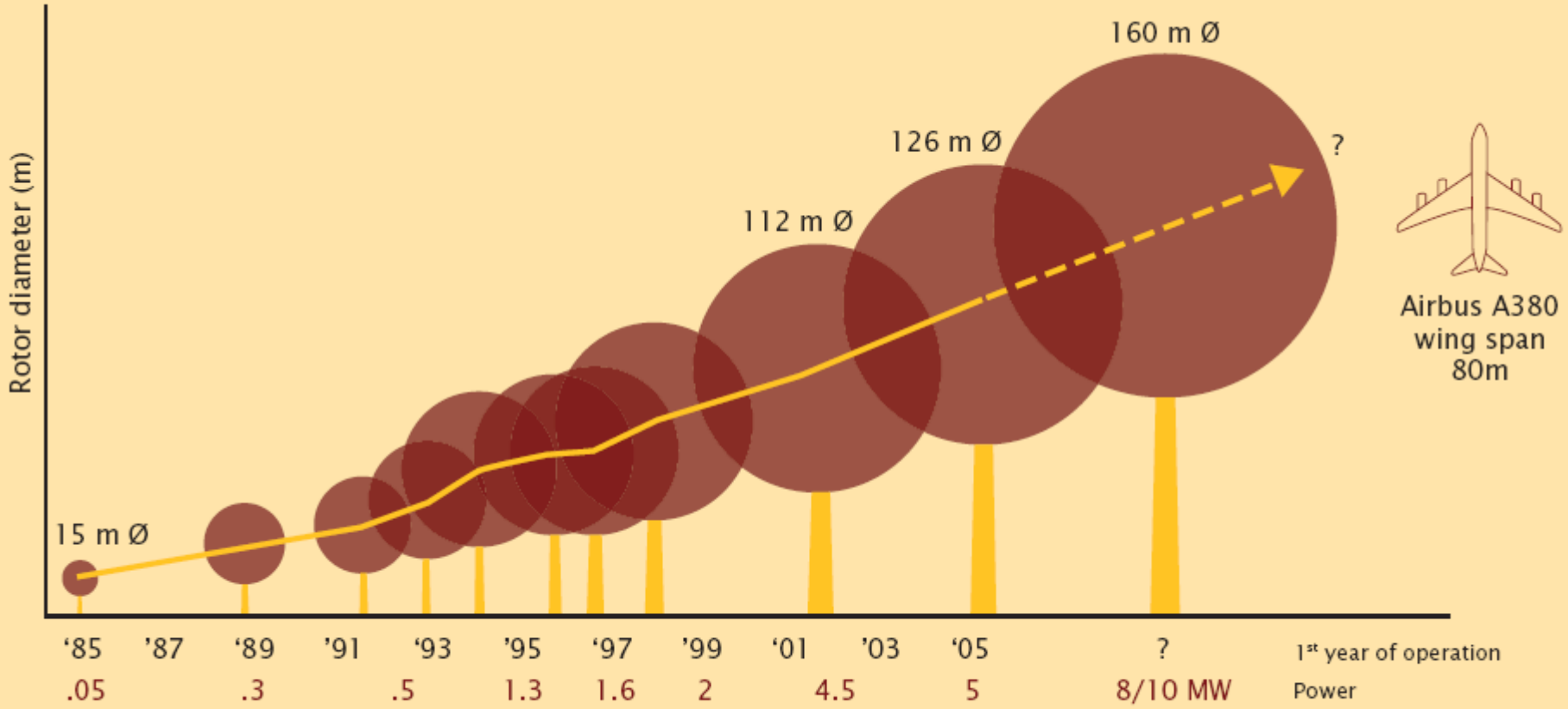
Li-Ion Batteries
Hydrogen storage



Energy - Saving

Lightweight materials for construction and transportation
Low rolling resistance tires / rubber
Efficient production processes
-Catalysis
-Electrostatic coating

Energy efficiency of windturbines



Evolution of the size of wind turbines

Source: http://ec.europa.eu/research/energy/pdf/renews5.pdf
UpWind Intgrated Project on Windturbine Design

Increase of efficiency by enlarged span of blades

Technical Challange:

The maximum strength of materials limits the size of windblades

Approach:

Reinforcement of materials by means of mixing with high strength additive, e.g. such as CNT

Approach to address technology challenges for sustainable energy conversion: Wind turbines

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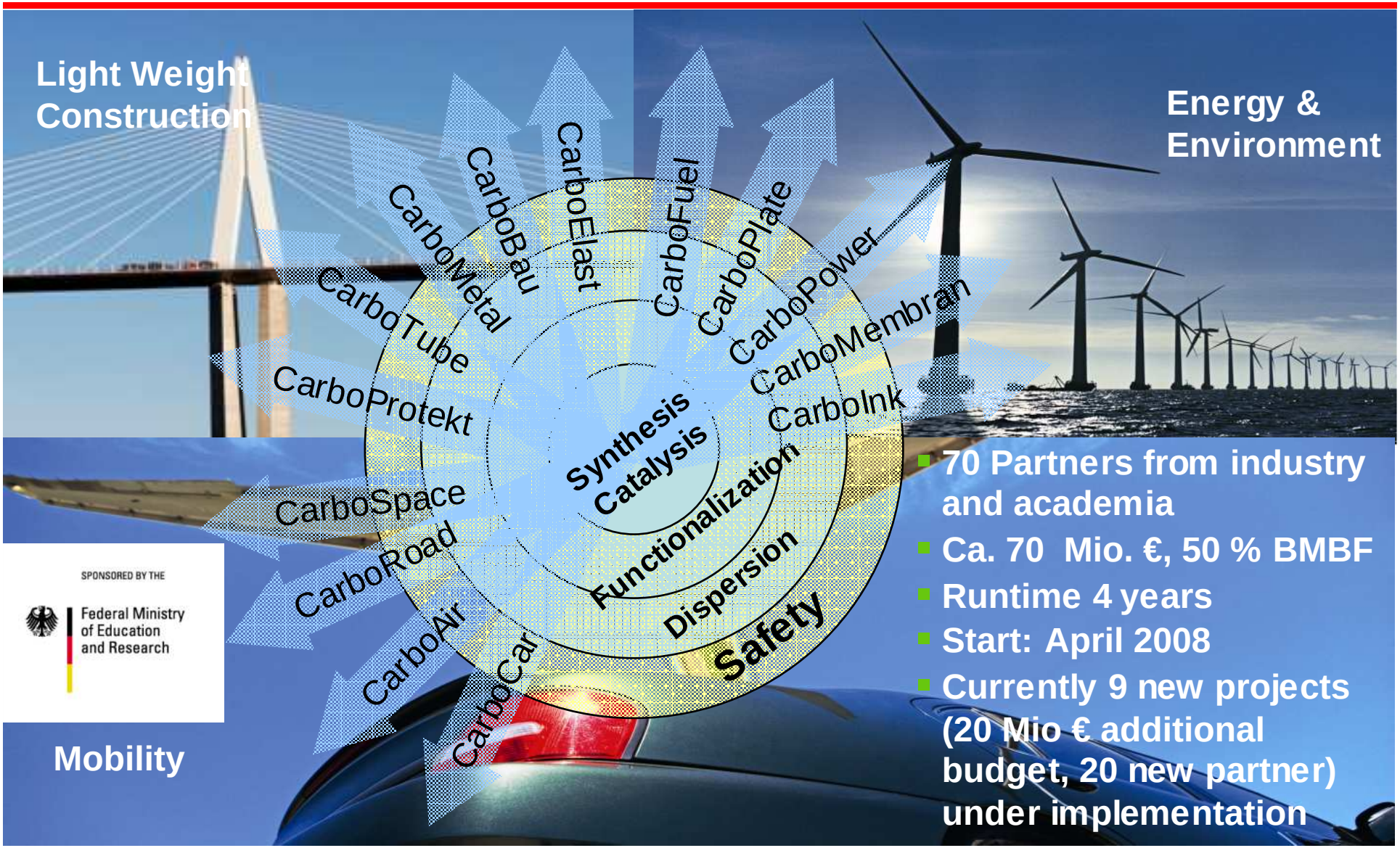
Value chain

Example: Innovation Alliance CNT,

www.inno-cnt.de

Inno.CNT

Innovation Alliance CNT: Cross-sectional platform technologies as a basic fundament for application projects



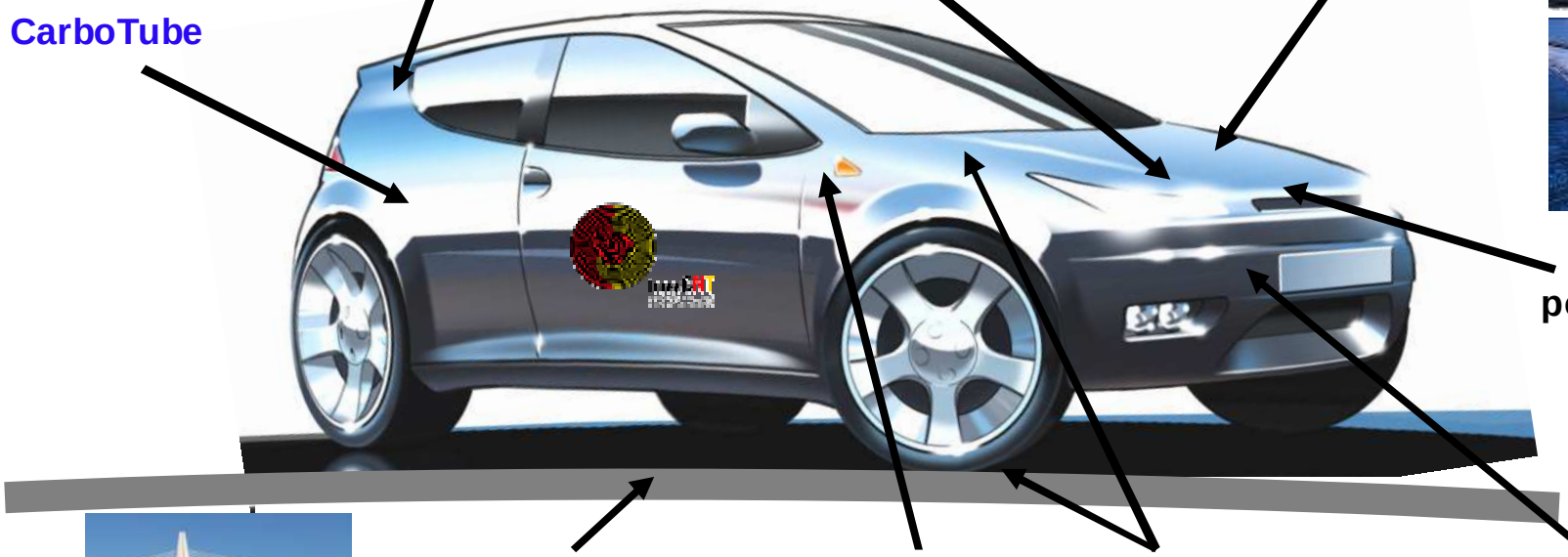
Innovation Alliance CNT: Application Examples for Automobiles

Light weight car body:
CarboCar
CarboMetal
CarboTube

Light weight structure elements:
CarboRoad
CarboMetal

Power supply for engine by fuel cells:
CarboPlate
CarboFuel

Energy storage in battery:
CarboPower



Sustainable power supply for engines:
CarboInk
CarboAir

Bridges based on light weight concrete:
CarboBau

Flexible electronics:
CarboInk

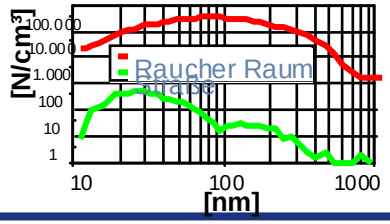
Energy savings by tires, sealings:
CarboElast

Passenger safety crash-elements:
CarboProtekt

Innovation Alliance CNT:

A large number of technology options for transportation is covered by projects in Inno.CNT

Product Stewardship for Nanomaterials at Bayer



Research and testing for the evaluation of exposure and bio activity profiles

Development and validation of Methods and Characterization

Participation on public supported projects: such as NanoCare, TRACER, CarboSafe

BAYER

Participation in associations: e.g. DECHEMA, VCI, CEFIC, ACC

Support globally harmonized standardization (ISO, OECD)

Participation on Dialog with Stakeholders

Safety research is an essential part of the innovation - strategy

Urgent Societal Needs and Challenges
Nanotechnology as a Cross-Sectional Platform

Energy

Conversion
Transport
Storage
Saving

Environment/Climate

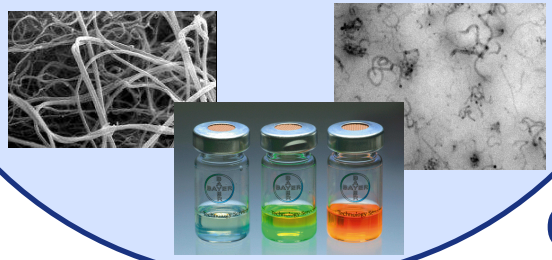
Decontamination:
-air
-soil
-water
Renewables

Resources

Saving, Efficiency
Catalysis,
Corrosion
protection

Nanotechnology

Nano-objects,
Nano-container
Nano-composites,
Nano-materials
Nano-structures

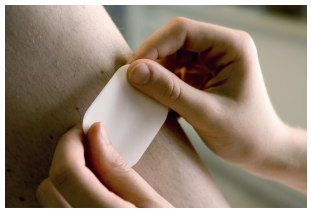


Mobility

Ground transportation
Aerospace
Marine

Health

Recovery:
-Drug delivery
-Controlled release
-Diagnostics
-Med. techn./equipments
Care/Conservation:
-Hygiene
-Sun protection

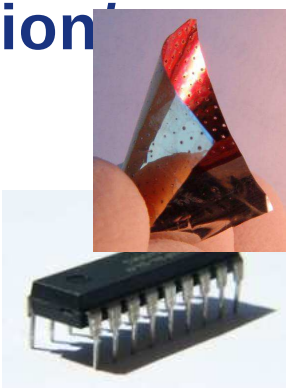


Nutrition

Plants / Crops
Clean water

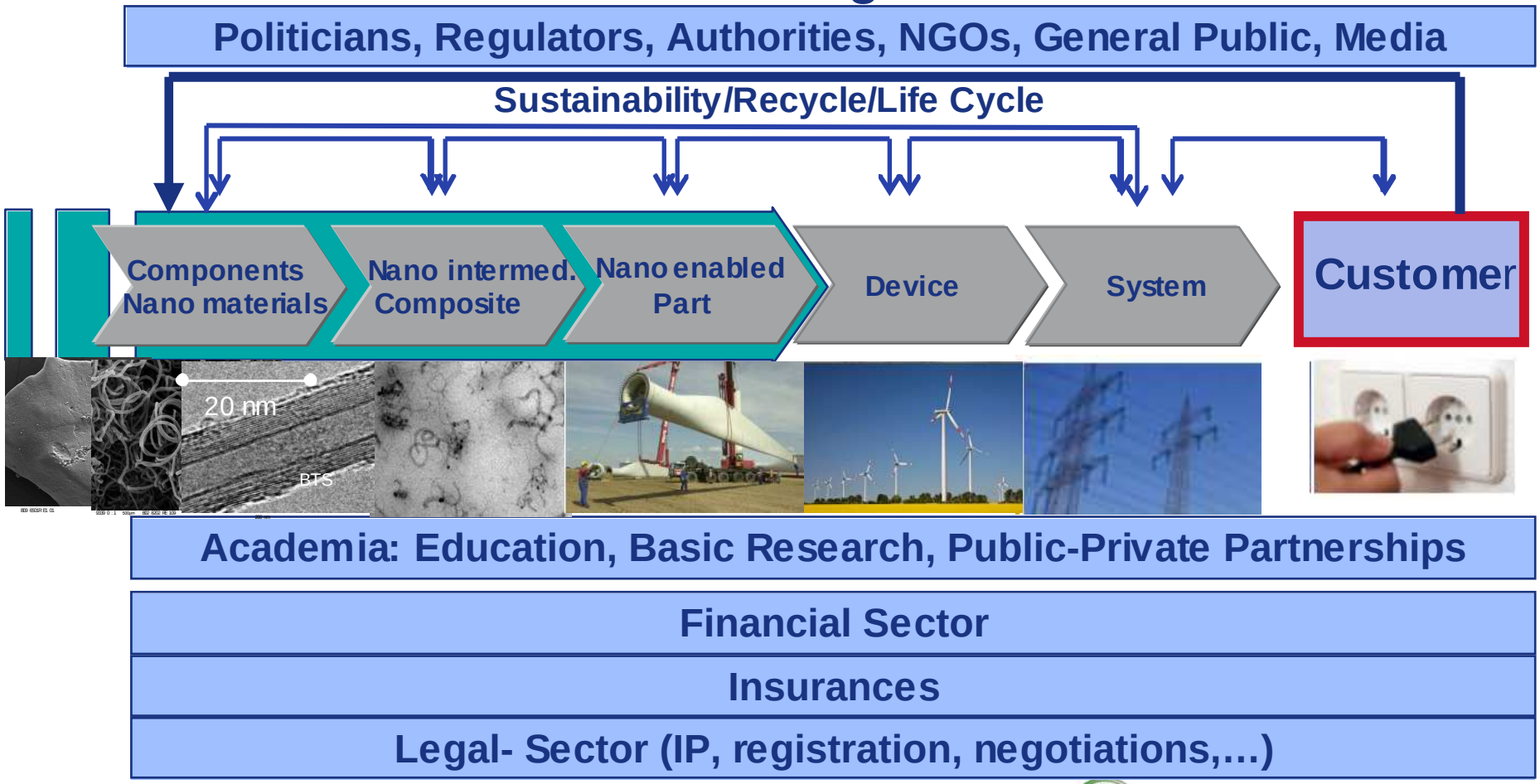
Communication/ Information

Data storage
Data processing
Displays



Nanotech is an Enabling Technology
along the value chain

Nanotech is in competition with established classical technologies



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Thanks for your attention!

Nanotech is Powerful

Working Group Nanotechnology

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Acknowledegements

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