SPITZENFORSCHUNG&INNOVATION
IN DEN NEUEN LÄNDERN

Nano System Integration

Towards Energy Efficient Sensor Systems

Dr. Danny Reuter

Innovations for Industry – Hannover, 06.04.2011

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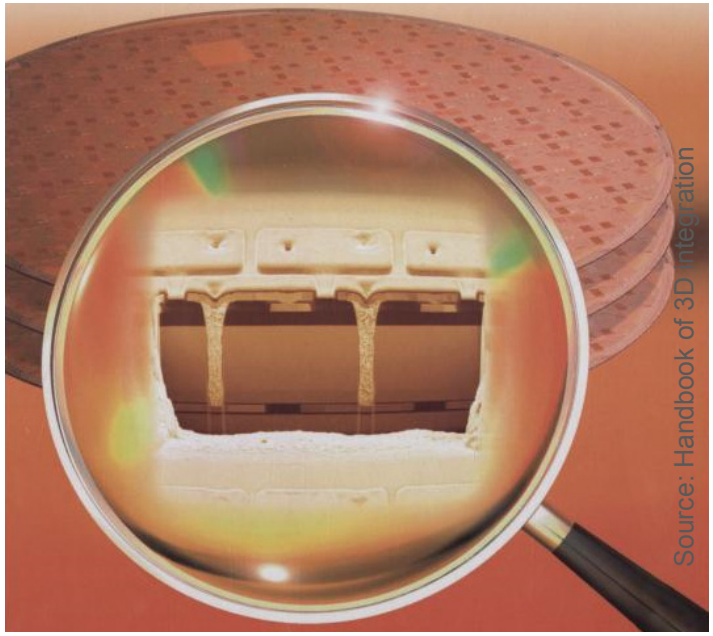
The changing landscape of micro- and nanotechnologies

New concepts and materials for nanoelectronics



Integrating more functionality while going to the nanoscale

Linking "More Moore" with "More than Moore"

towards

Smart Systems Integration

Dr. Danny Reuter
Fraunhofer ENAS
TU Chemnitz, ZfM
06.04.2011

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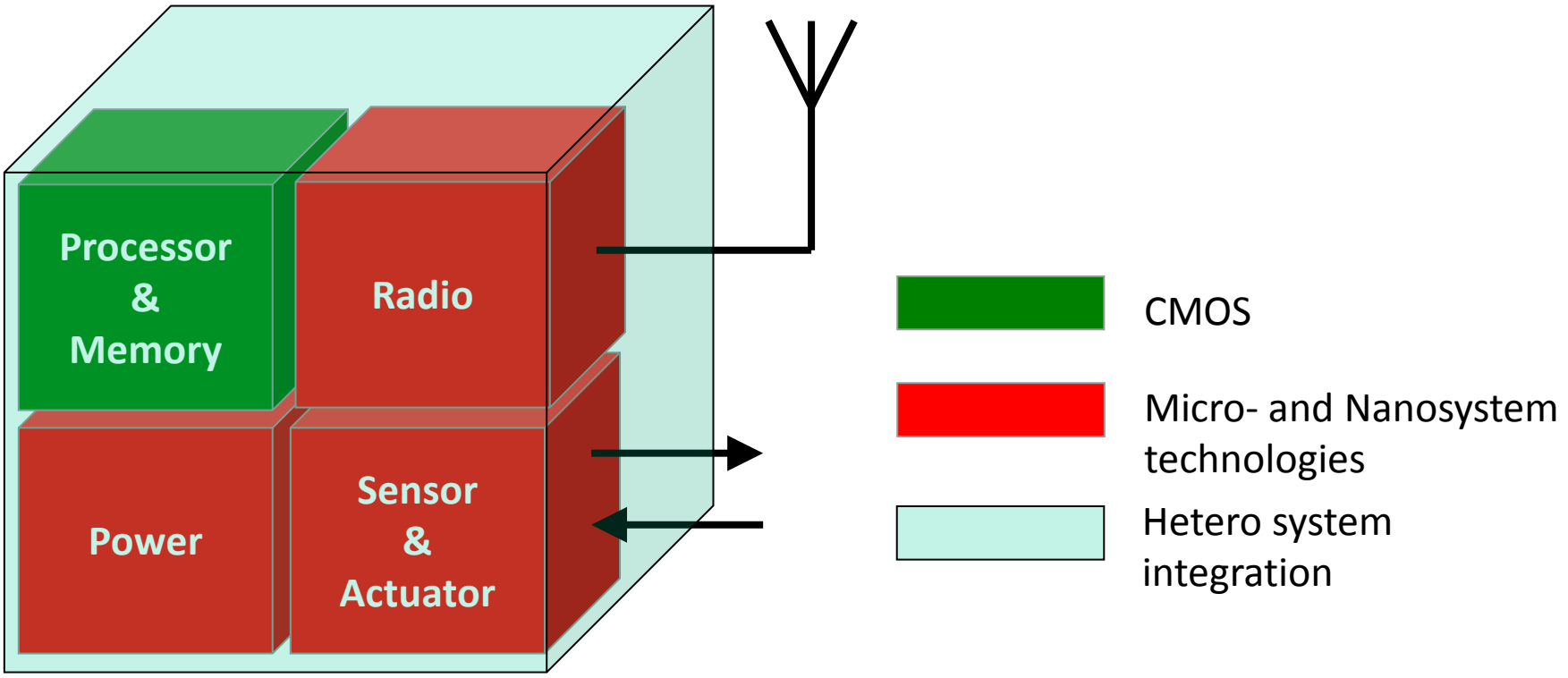


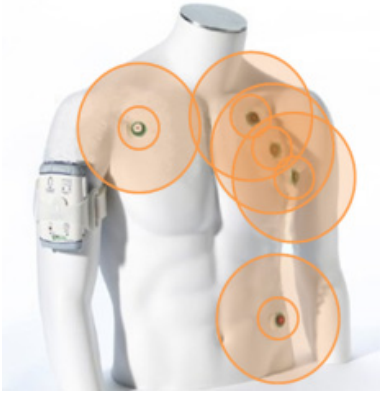
- **Future trends are increasing functionality in one system at the same time with decreasing size**

→ Nanosystems

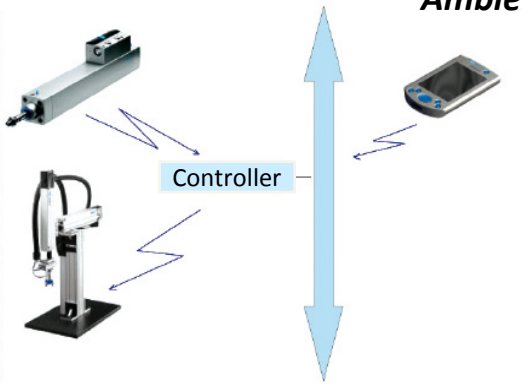
Energy Efficient Autonomous Sensor Systems

Condition Monitoring

Ambient Intelligence



Body Area Network for Medical Applications



Remote Control in Production Lines

Environmental Monitoring

Dr. Danny Reuter
Fraunhofer ENAS
TU Chemnitz, ZfM

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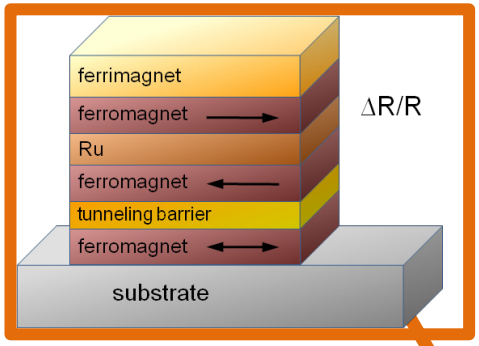
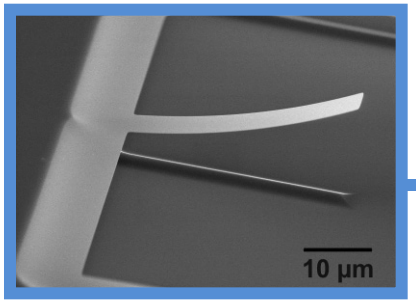
Research Fields of the Network

Novel Processes and Technologies

Nano Scale Material Systems for magnetic Sensor Applications



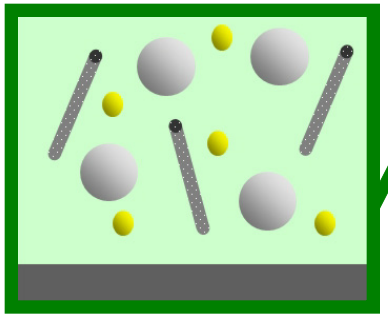


Micro-Nano-Integration

NEMS/MEMS-Electronics Integration for Energy Efficient Sensor Nodes

Nano Materials

Material Integrated Sensor Functionality Based on Nano Effects



Dr. Danny Reuter
Fraunhofer ENAS
TU Chemnitz, ZfM

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Projects of the network

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Phase 1: Integration at the Component Level (3 Years, Funding by BMBF)

Flagship project A:
Nano scale material systems for magnetic sensors

Flagship project B:
NEMS / MEMS electronics integration for energy efficient sensor nodes

Flagship project C:
Material integrated sensors based on nano effects

Phase 2: Integration at the System Level (2 Years, Funding by BMBF)

Joint Project A+B:
Hybrid oder monolitic integrated NEMS / MEMS

Joint Project B+C:
Modules with nano based distributed functionality

Associated Projects in cooperation with the industry (2 - 3 years, Funding by state of Saxony)

Associated Project 1:
Spintronic sensor systems

Associated Project 2:
Sensor integration by Through Silicon Via

Associated Project 3:
Bistable display for transport monitoring

Dr. Danny Reuter
Fraunhofer ENAS
TU Chemnitz, ZfM

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Goal: Realisation of novel nano patterned spintronic elements

Materials / Deposition

- Novel exchange bias film systems for Spintronics
- ALD: magnetic materials and tunneling barriers
- Flexible substrates

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Nanopatterning

- Laser interference lithography
- Nanoimprint / E-Beam
- Layer modification by Laser exposure

HELMHOLTZ ZENTRUM BERLIN für Materialien und Energie

HOCHSCHULE MITTWEIDA UNIVERSITY OF APPLIED SCIENCES

Characterisation

- Structural and magnetic properties at the nano scale

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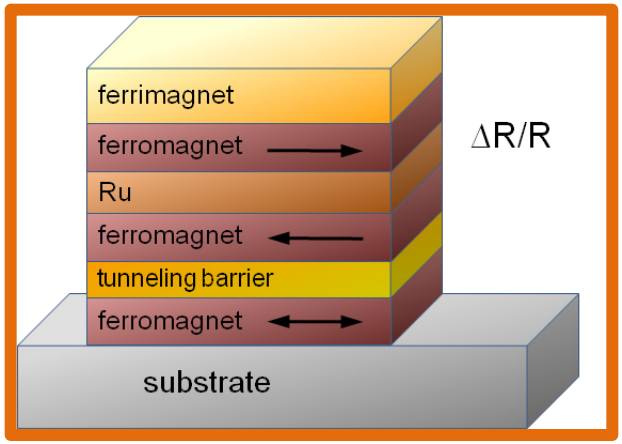
Fabrication of novel film systems for Spintronics:

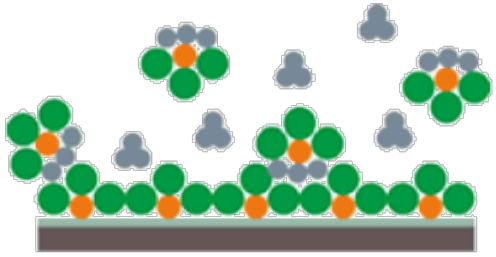
+ GMR/TMR-systems
+ Exchange bias systems (FeTb/Co)

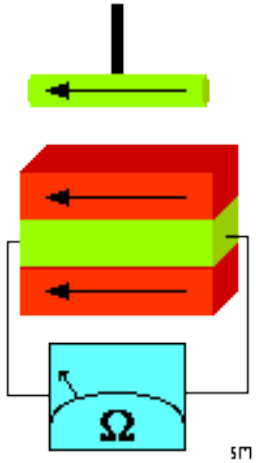


- Sputter und MBE deposition

- ALD deposition (Precursor development)

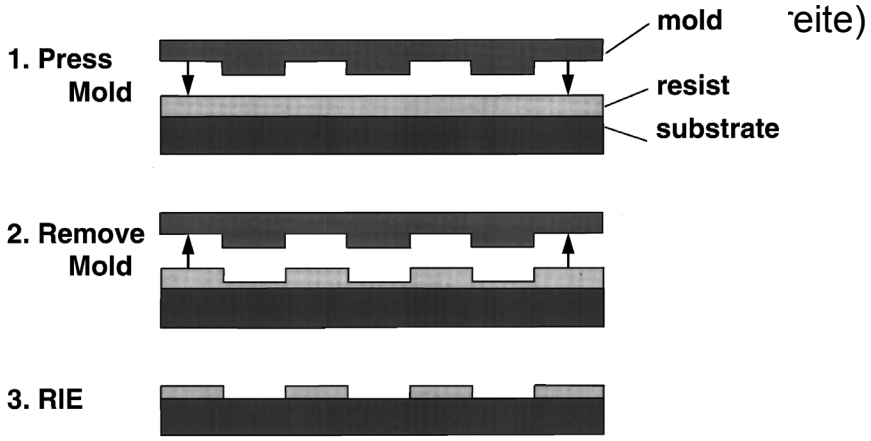
- Flexible substrates (GMR effect)





Nanopatterning

- Nanoimprint lithography (NIL):
  - Development, Fabrication, Test of the Imprint tools
  - Modification of the technology
- Laser interference lithography (LIL):
  - Sub micro patterning, Ultra short laser pulse
  - Modification of the magnetic properties by Laser annealing



Teilprojekt 3

SQUID-VSM, MOKE Magnetometry

Magneto-transport properties (TMR, GMR)

SP-Scanning Tunneling Microscopy

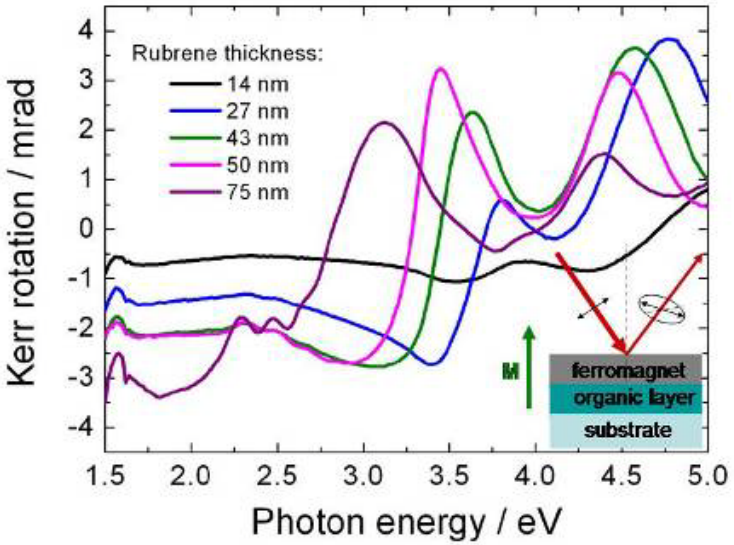
Magnetic Force Microscope

Ellipsometry (BESSY, Synchrotron Radiation (4-30 eV)

Raman-Spectroskopy

X-ray Structural Analysis

Transmission Electron Microscopy



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Goal: Novel technologies for autonomous multi functional smart microsystems

MEMS/NEMS technologies

- Monolithic integration in CMOS (NEMS/MEMS, TSV)
- Hybrid integration (RF-NEMS)
- Modelling
- Application

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ihp innovations for high performance microelectronics

Sensor network

- Software concepts
- Communication protocolls, self exploration and energy efficient communication
- Simulation of network scenarios

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Energy management

- Novel energy
- Micro-/nanoscale storages
- Intelligente energy management
- Low power electronics

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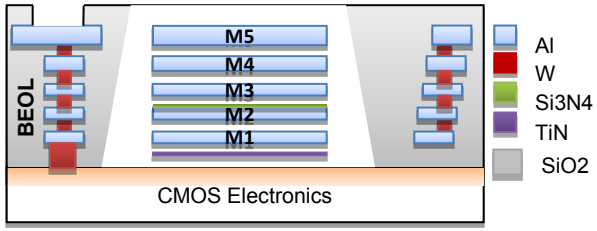
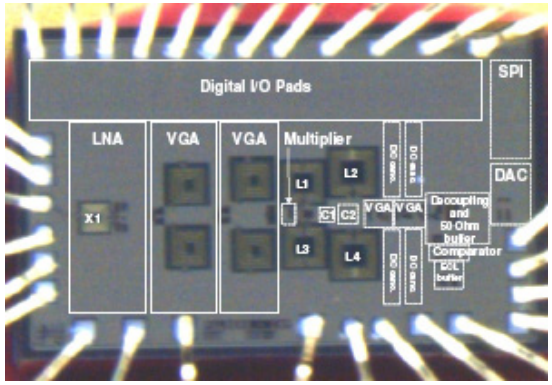
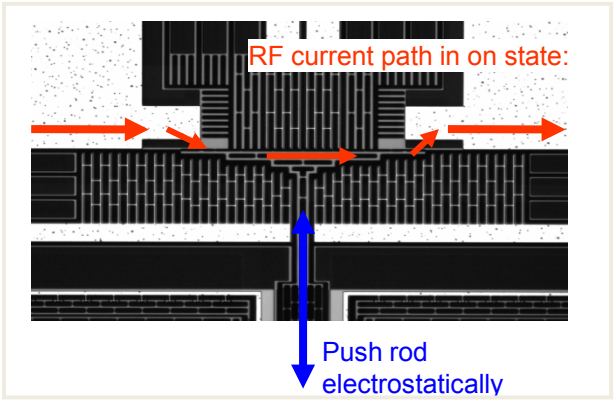
MEMS/NEMS technologies – Integration of Wake up receiver for energy efficient sensor nodes

- Integration of MEMS/NEMS to BiCMOS
  - Integration to BEOL
  - Substrate Etching
- RF Electronics
  - RF Circuit Design
- Sensor Systems and Applications
  - Wireless Systems Design



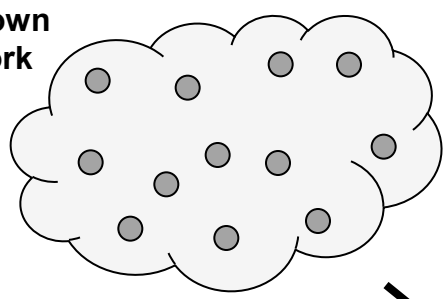


UWB RX IC

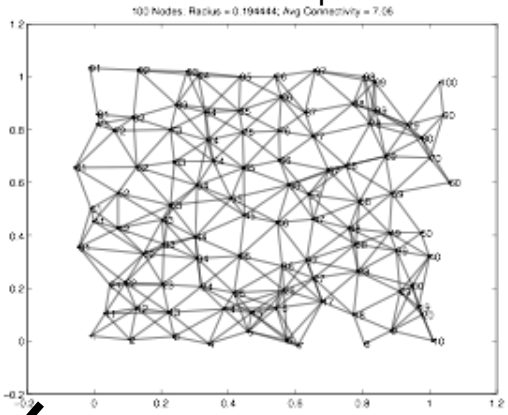


Sensor network

- Identification of node properties and neighbore relation
- Initialization of the application



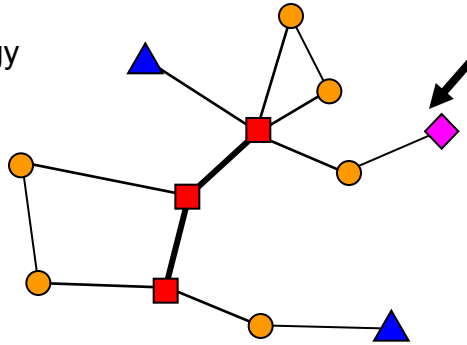
Explored Network
- Connectiviy
- Node properties
- Information about position



Source: Giorgetti et al., IPSN'07

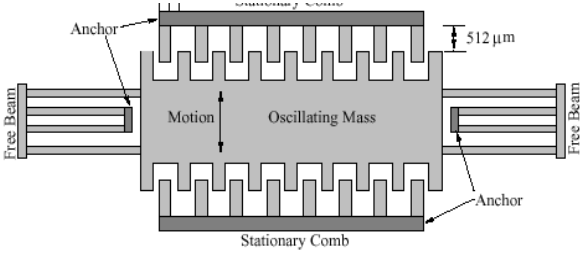
- Determination of the net layout
- Determination of the node position
- Geographic Routing
- Mapping of the measurements to the locations

Intelligent Network
- Optimized communication strategy
- Efficient use of resources

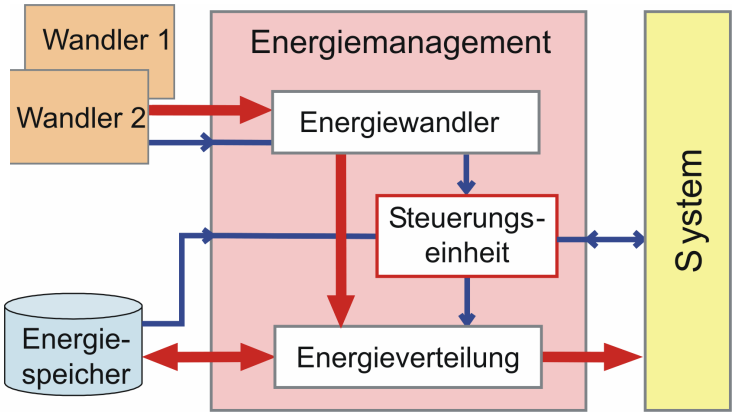


Energy management

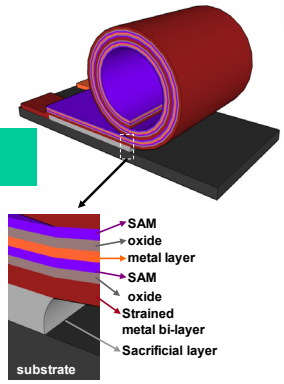
Conversion



Intelligent distribution



Storage



Low power Electronics

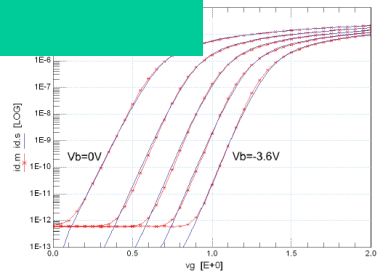


Abb.: Übertragungskennlinie eines NMOS-Transistors, W:20 µm, L:20 µm bei Vds = 0.1V

Goal: Novel materials with integrated functionalities based on nano effects

Novel materials

- Electroactive polymers
- Nanocomposites
- Nanotubes
- Functional polymers

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Fraunhofer IAP

Leibniz-Institut für Polymerforschung Dresden e. V.

Leibniz-Institut für Festkörper- und Werkstoffforschung Dresden

System integration

- Integration of sensor and actor systems
- Integration of power supply
- Interface nano-micro-macro

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Application

- Direct material control
- Adaptive and self healing materials
- Condition monitoring
- Energy harvesting

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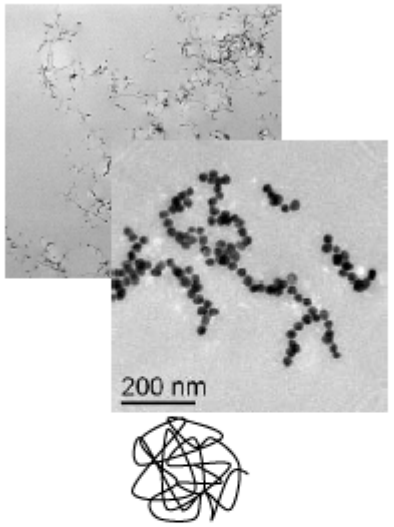
Novel materials

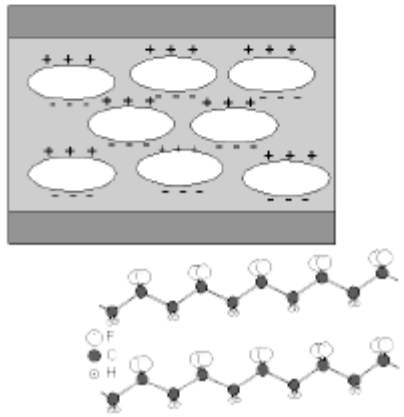
Conductive Quantum dot nano composite

- Quantum dots comercial available
- conductive matrix by usage of CNTs, integration of metallic nano particles and functionalized Polythiophene



Piezoelectric polymers and nano composites

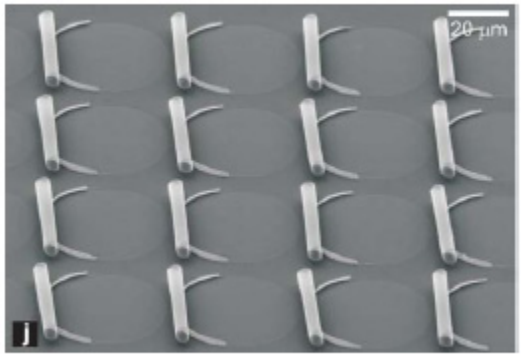
- Development of piezoelectric materials on the base of polymers
- Use of ceramic piezoelectric nano fillers and sensitive cellular piezoelectric polymer films

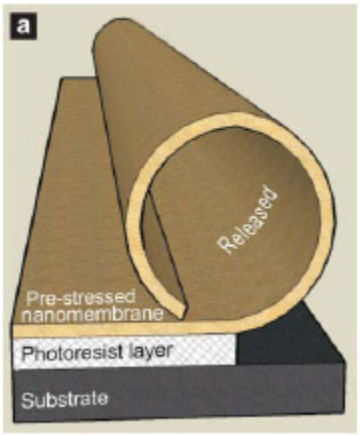


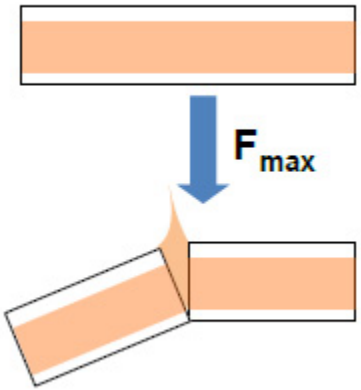
Novel materials

Smart tubes

- Micro and nano tubes of diverse materials and combinations of that (semiconductors, metalls, oxides)
- Analysis and adaption of mechanical properties to the crack calibration
- Technology development for the scaled fabrication



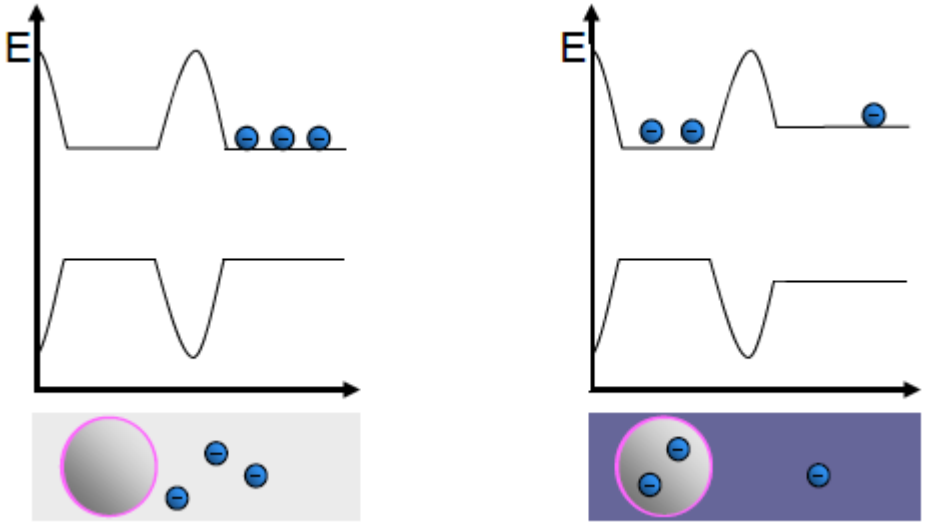




Sensor Systems

Sensor design and simulation

- Design of the sensor systems (mechanical, electrical)
- Fundamental investigation of the conducting effects in the quantum dot composite
- Simulation for the extraction of material parameters
- Technology development for integratable sensor systems



Conclusion

- The strategic direction of the network is the connection of fundamental with application oriented research in the promising domains of nanotechnology and system integration technology

- Combining the capabilities of several renowned scientific institutions enables international and domestic top level research on a competitive basis

- Using synergies created by the collaborative work of different renowned research centers is essential to suit the scientific requirements of these highly interdisciplinary field and due to huge investment costs

- The aims of the network are the transfer of science into applications and being an attractive, competent and solid partner for the industry

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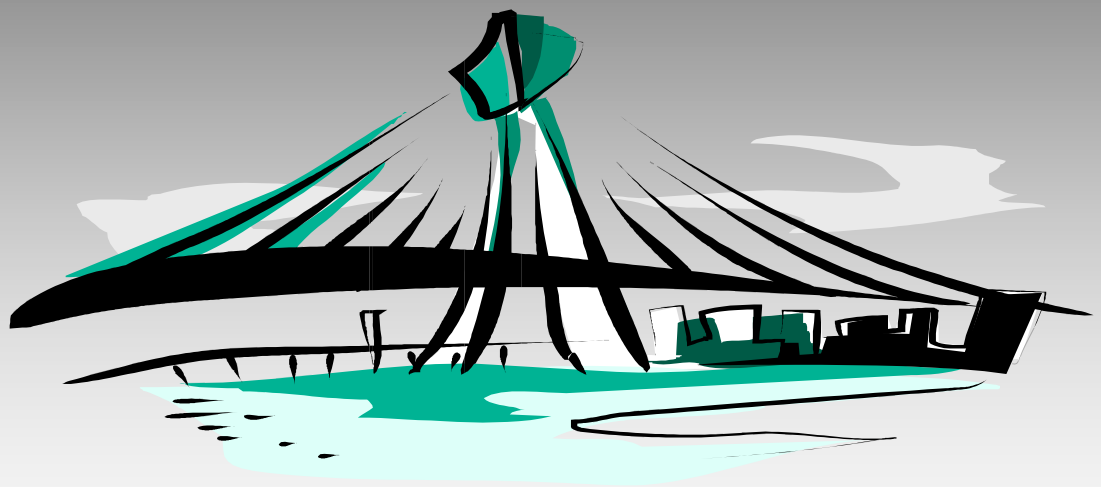

Bridging the Gap between Nano and Application

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