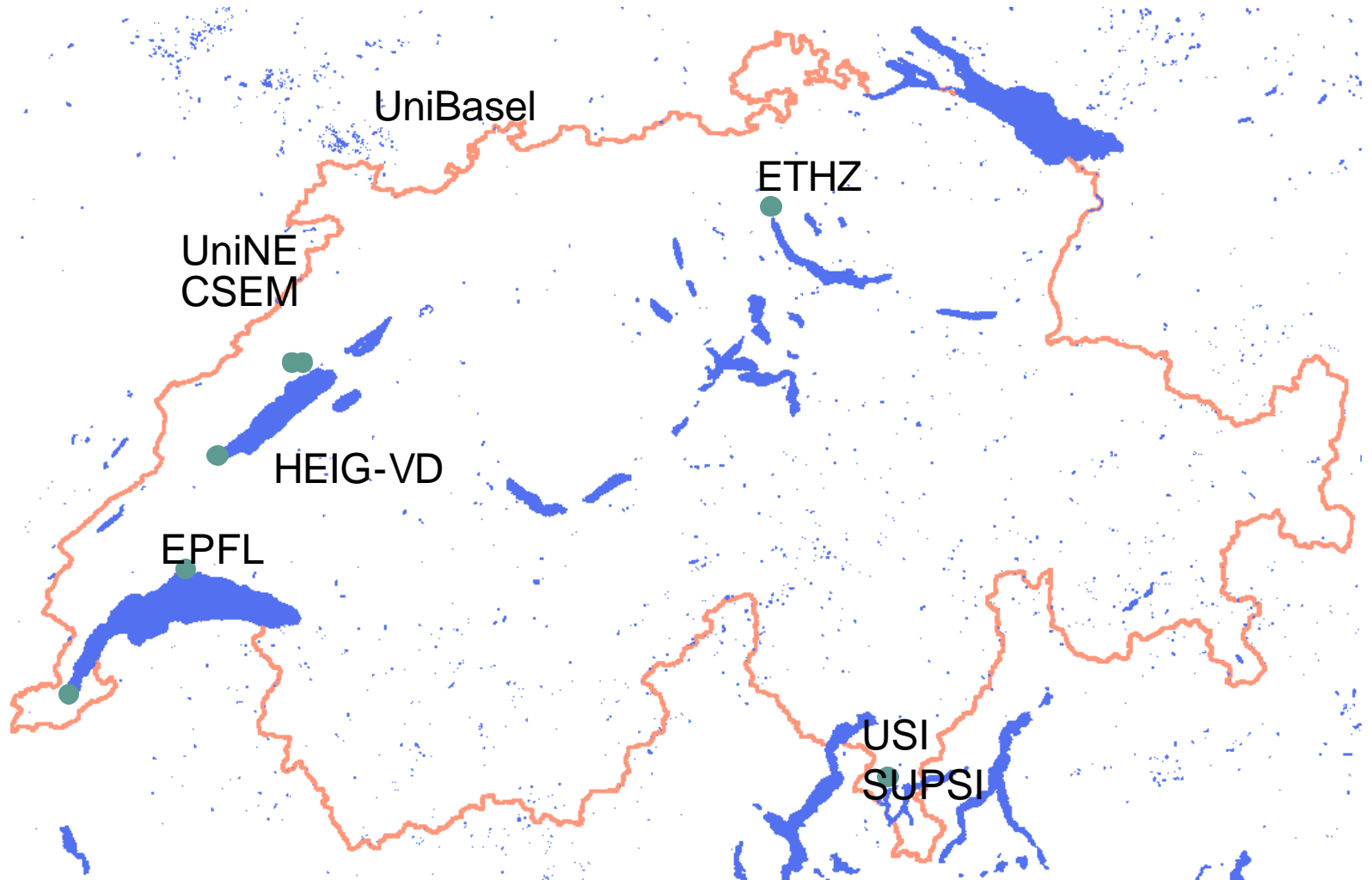# Engineering Systems for
Health, Security and the Environment

Giovanni De Micheli – Spokesperson
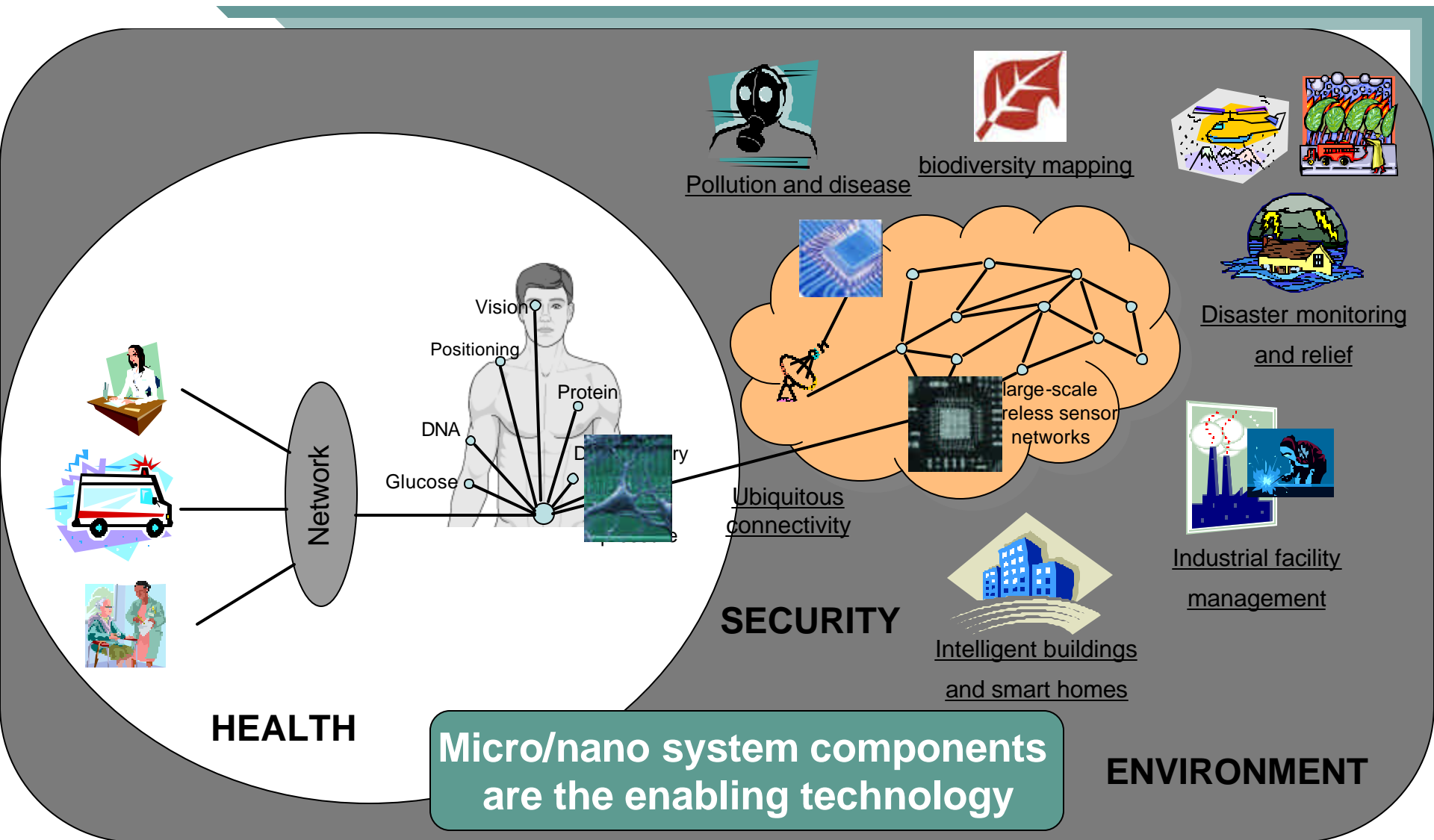
www.nano-tera.ch

Objectives

- Create a *collaborative research program*
  - Micro/nano-system engineering for
    tera-scale distributed embedded system design

- Develop an *educational program*
  - New courses and curricula

- Construct *demonstrators* of the technology
  - Engineer complex systems

- *Transfer results* to the Swiss Industry
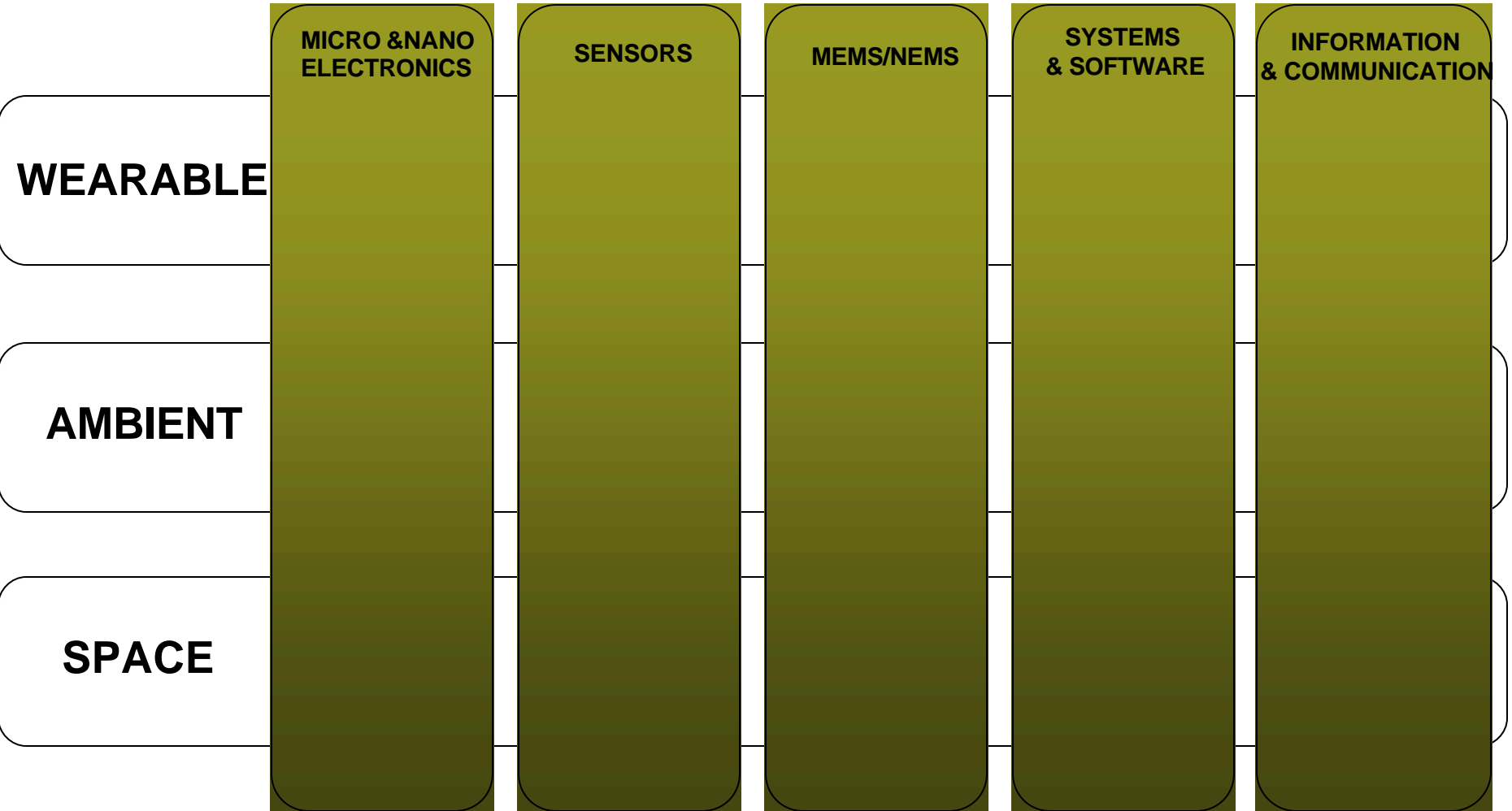 - Involve industry as R&D partner

Partner Institutions

UniBasel

ETHZ

UniNE
CSEM

HEIG-VD

EPFL

USI
SUPSI

Vision

Pollution and disease

biodiversity mapping

Disaster monitoring and relief

large-scale wireless sensor networks

Ubiquitous connectivity

Industrial facility management

Vision
Positioning
Protein
DNA
Glucose

Network

SECURITY

Intelligent buildings and smart homes

HEALTH

Micro/nano system components are the enabling technology

ENVIRONMENT

Technical Scope

	MICRO &NANO ELECTRONICS	SENSORS	MEMS/NEMS	SYSTEMS & SOFTWARE	INFORMATION & COMMUNICATION
WEARABLE					
AMBIENT					
SPACE					

Application areas

- ## Wearable
    - Monitor human body: sportsmen, elderly, sick
    - Disease prevention and advanced therapy

- ## Ambient
    - Monitor environment through distributed sensing
    - Enhance security on the individual and population

- ## Space
    - Environmental monitoring on a global scale
    - Perform micro-experiments in space

Wearable Embedded Systems

- Wearable embedded computing:
  - High-performance, power-efficient
  - Non-intrusive, embedded into small personal device

- Wearable embedded systems require novel technologies for:
  - Sensing and bio-interfaces
  - Wireless body area networks for pervasive computing
  - Integration for small-form factor
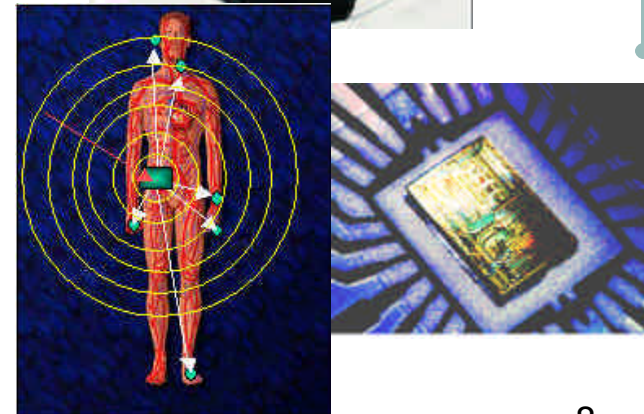
Ambient Systems

- **Wireless sensor networks**
  - Environmental monitoring, ambient web
  - Extended to the physical/molecular level with bio-sensing

- **Security of the elderly by ubiquitous connectivity**
  - In the home, car, territory
  - Positioning, proximity to danger, alerts

- **Means for tracking diseases and disasters**
  - Migratory bird flu
  - Floods, avalanches, tidal waves, …

Space Systems

- **Nano/Pico-satellites**
  - Small, cheap, application-specific
  - Swarms of satellites
  - Inspector satellites piggy-backed on larger satellites
- **Applications**
  - Environmental monitoring
  - Scientific experimentation

- **Pico-satellites require a new set of electronic components**
  - Higher integration, lighter, ultra-low power
 - Application-specific micro-systems for space
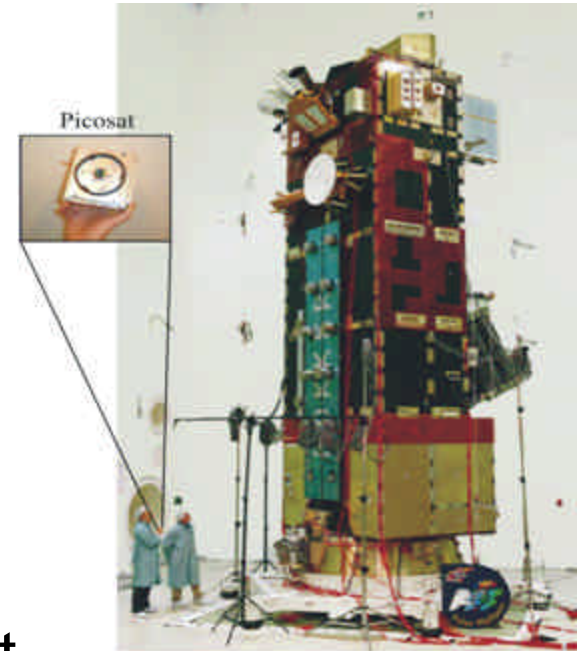
# Enabling Technologies

- **Micro/Nano electronics**
  - Novel functional materials and processing means
  - Enable ubiquitous distributed computation
- **Sensors**
  - Biological and inorganic sensors
  - Front end of health and environmental systems
- **MEMS/NEMS**
  - Technology hybridization
  - Energy sources and harvesting
- **Software and Systems**
  - Reliable multi-processors software systems
  - Large-scale information management
- **Information and Communication**
  - Large-scale information processing
  - Data security in ubiquitous wireless communication

Micro/Nano-system Technology

- **Micro/nano circuits provide the underlying computing/communication mechanisms**
    - New materials to improve current technologies
    - New device structures for computing, storage and sensing
    - New circuit patterning means

- **Hybridize micro-technologies with revolutionary nano-technologies**
    - Integrated computation and sensing
    - New functionality
   - New circuits and architectures
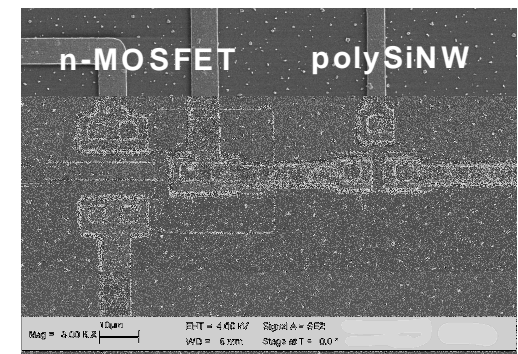
Some Research Topics

- **Materials and devices**
    - Heterogeneous integration
    - 3-Dimensional chips

- **New circuits and architectures**
    - Micro/nano interfaces
    - Predictable array-logic design

- **Design technologies for micro/nano-systems**
    - Very low-voltage operation
    - Reliability and fault tolerance

MEMS/NEMS
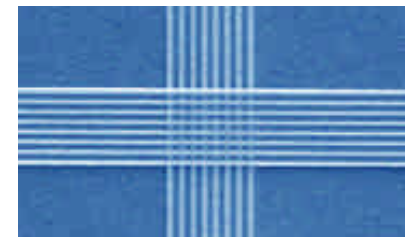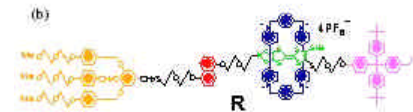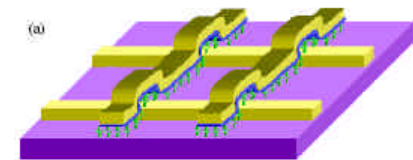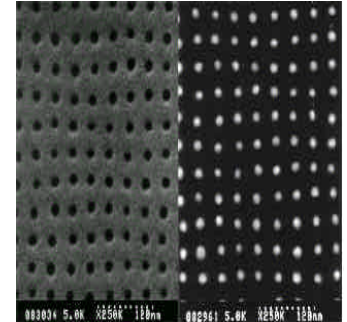
- **Micro/Nano Electro-Mechanical Systems**
  - Seamless integration of mechanical and electrical devices
- **Sensors and actuators**
  - Micro-mechanical feedback systems
- **Advanced biochemical systems**
  - Drug delivery
  - Artificial organs
- **Integrated micro/nano-fluidics**
  - Lab on chip

Software and Systems
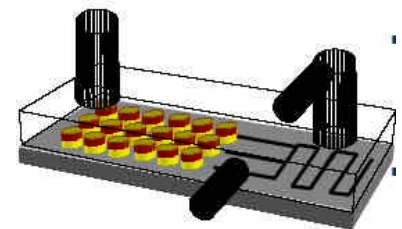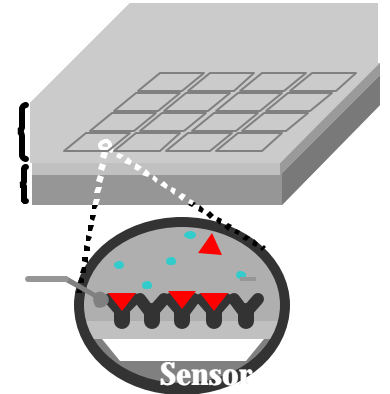
Tera-scale distributed information systems require novel tools and concepts at the levels of:

- **Software infrastructure**
  - Resource usage
  - Reliability and fault-tolerance
  - Predictability
  - Security

- **Large-system infrastructure**
  - Processing
  - Storage
  - Retrieval

Information and Communication

- **Wireless sensor networks**
  - Meaningful and efficient transmission and processing of information gathered by large number of sensors
  - Transmission security and reliability
  - Low-cost, ultra-low-power transceiver architectures

- **High-end wireless communications**
  - Low-complexity signal processing
  - VLSI implementations
  - Low-power solutions

Conclusions

- **An ambitious collaborative project**
  - Various universities and research centers
  - Involvement of local industry

- **Engineer complex systems by leveraging micro/nano-system technology**

- **A social objective to create enthusiasm among students and support from the people**

- **Creation of new products, jobs and growth**