Fraunhofer ENAS

Fraunhofer ENAS – Rainer Kaltschmidt

Miniaturization – not only - in Medical Engineering

Fraunhofer and the universities

Synergies through complementarity

Dual appointment to Fraunhofer and university

scientific and entrepreneurial competence

University:
Research and education

Fraunhofer Institute:
Applied research and transfer

understands the needs of industry

educates the next generation of scientists

Both partners are always at the cutting edge of technology
→ Collaboration accelerates the transfer of knowledge

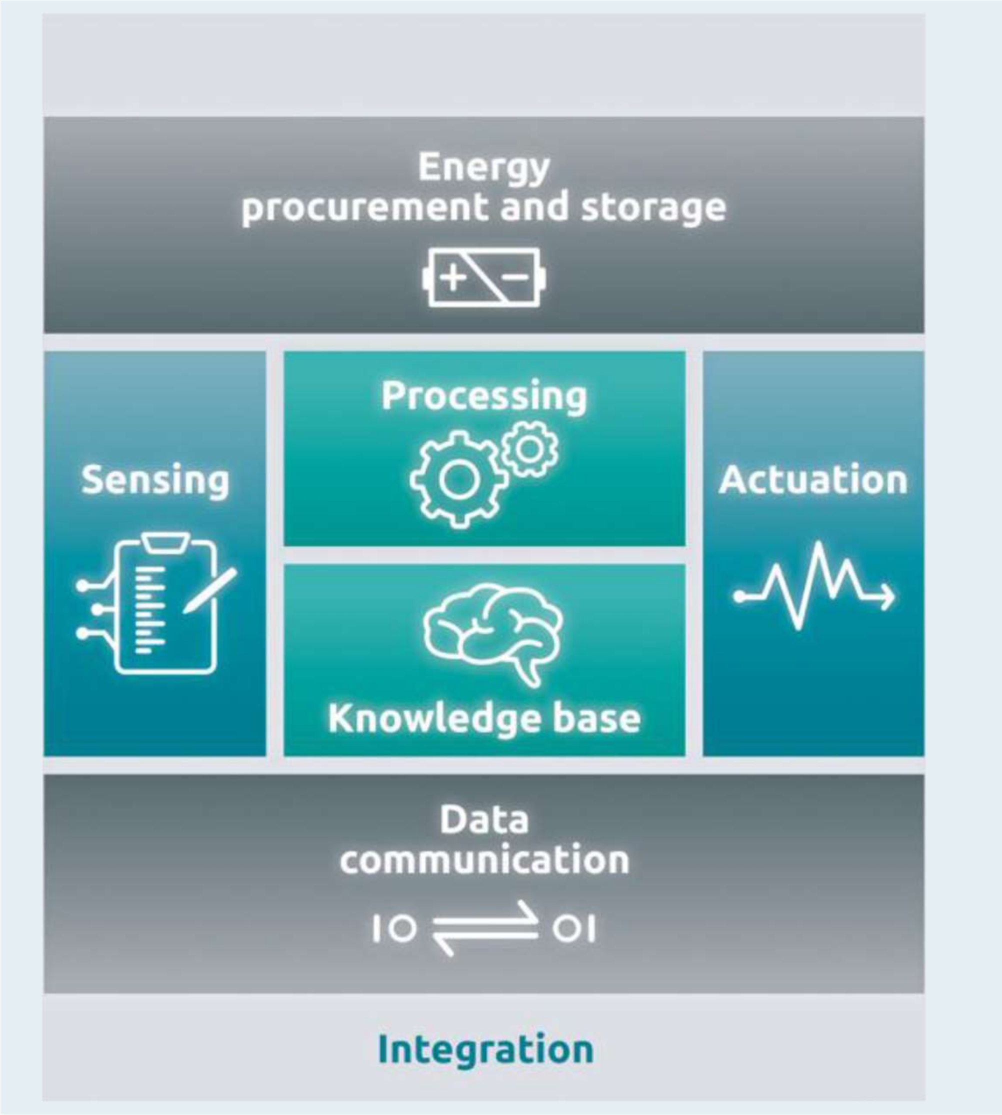
Fraunhofer ENAS and Center for Microtechnologies (ZfM) at TU Chemnitz

Cluster of clean rooms at ZfM: 1000 m^2, 300 m^2 of them are class ISO 4
Fraunhofer ENAS: 1400 m^2 of laboratories, 400 m^2 of them with improved cleanness

Main Working Field – Smart Systems Integration

- Self-sufficient intelligent technical systems or subsystems with advanced functionality
- Combine sensing, actuation and data processing, informatics / communication
- Autonomous systems
- Highly reliable, often miniaturized, predictive, linked in networks
- Their operation being further enhanced by their ability to mutually address, identify and work in consortia

→ **Basic components for the Internet of Things**



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Business Units
of Fraunhofer ENAS

Process, Device and Packaging Technologies

- Modeling and simulation of techno-logical processes and devices
- Micro- and nanotechnological processes
- 3D / MEMS Packaging
- MEMS technology platforms
- Nanotechnology components and systems

Intelligent Sensor and Actuator Systems

- Inertial Components and Systems
- Microfluidics for Lab-on-a-Chip Systems
- Optical Components and Systems
- Hybrid and Wireless Sensors and Systems
- RF Components and Systems

Systems and Applications

- Technologies
- Methodologies
- Customer Domains
  - Semiconductor industry, microsystems technology, system suppliers
  - Mechanical engineering, robotics, mobility
  - Medicine and MedTech applications
  - Energy, hydrogen technologies inclusive
- Regulatory Competencies

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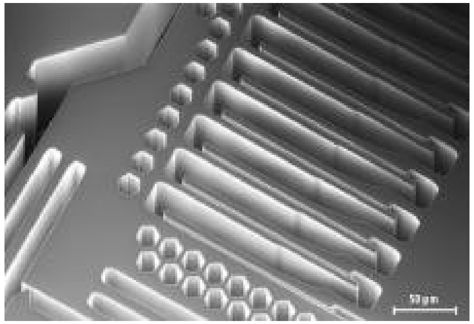
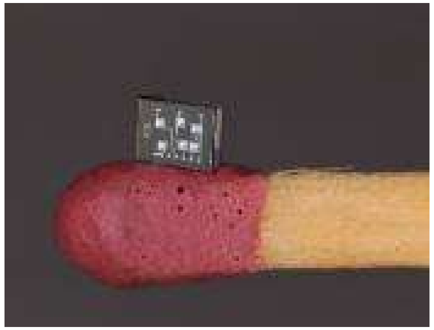
Why MEMS and Microsystems in Medical Devices ?

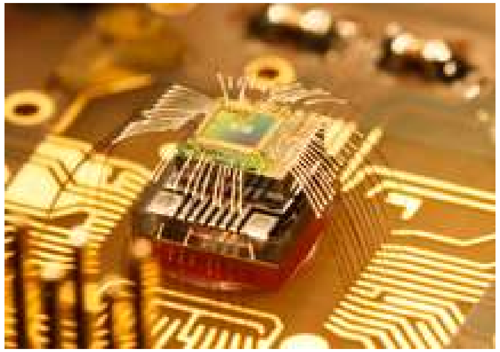
- **What is MEMS?**
  - MEMS stands for Micro Electro Mechanical Systems
  - A technique of combining Mechanical and Electrical components together on an chip to produce a system of miniature dimensions

- **Why MEMS for sensors?**
  - Smaller in size, so cheaper due to mass production
  - More sensitive to input variations
  - Have lower power consumption
  - Less invasive than larger devices

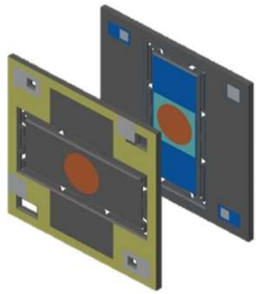
- **Challenges for MEMS in medical sensors?**
  - Life of the device
  - Biocompatibility → biggest hurdle
  - Resist drifting along with the body fluids
  - Retrieving data out of the devices



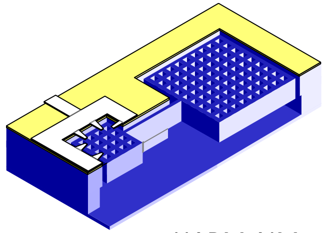




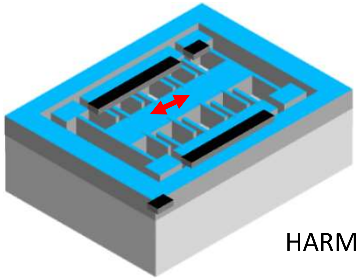
MEMS technologies



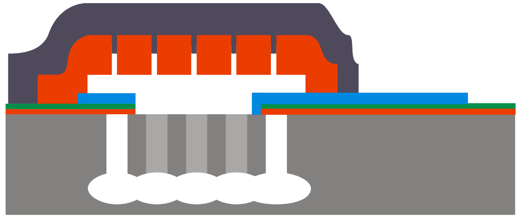
Bulk



HARM AIM



HARM BDRIE



Thin film

MEMS processes

- Lithography
- Wet etching
- Dry etching
- Layer deposition
- Wafer thinning
- Surface treatment
- Wafer bonding

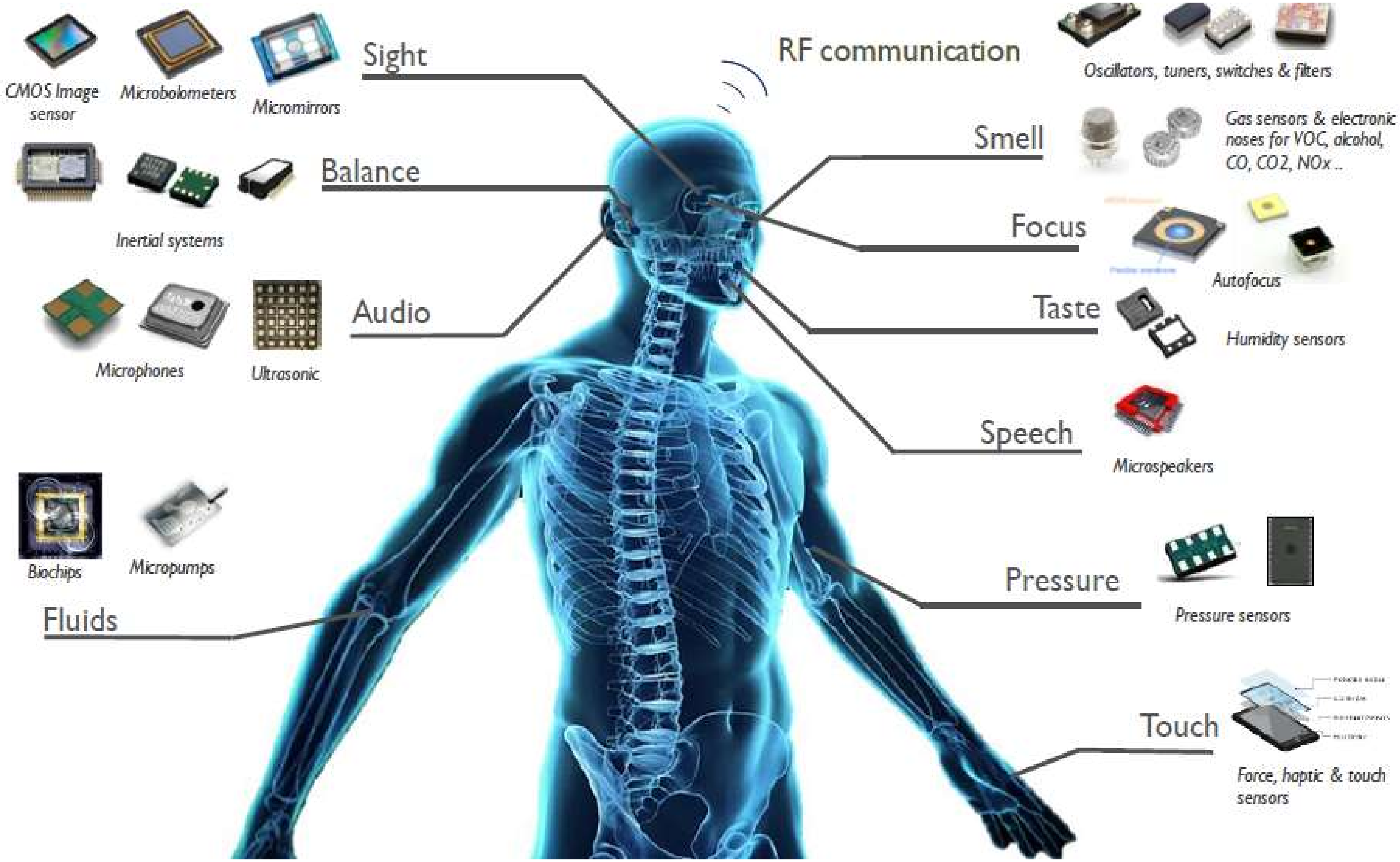
MEMS Technology flows

- Bulk technologies (with membranes and optical layers/gratings)
- HARM technologies for capacitive MEMS
- Gap reduction technologies
- AlN technology for piezoelectric MEMS
- Thin film encapsulation

MEMS Devices

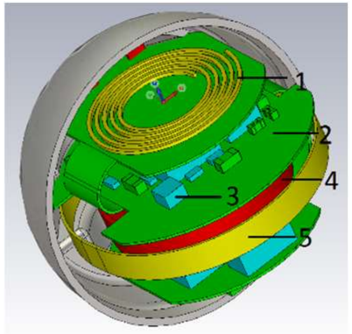
- Acceleration sensors
- Angular rate sensors
- Fabry-Perot filters
- HF switches
- MEMS speaker
- Ultrasonic transducers
- …

Status of MEMS for medical applications



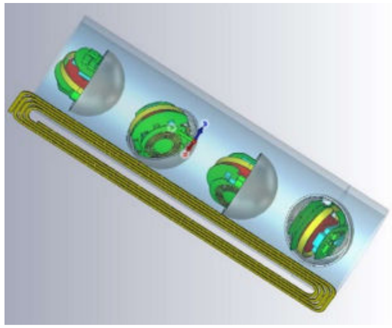
Sens-o-Spheres

Location-independent measurement capture in biotechnology

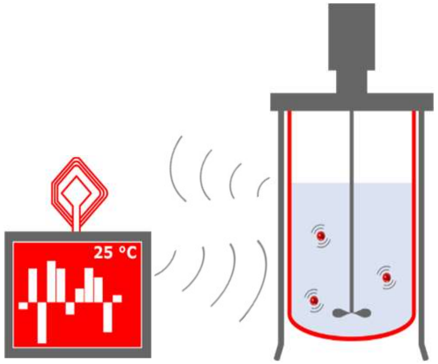


Internal structure

Size comparison



Charging concept



Intended use

Demonstrator Setup

General

- Measurement of temperature, pH value, etc.
- Spheres are directly involved in the process
- Fully encapsulated electronics
- Highly miniaturized spheres
- Wireless charging
- Next steps: Localization of the spheres

Results

- Functional proof of the demonstrator in laboratory use
- Charging concept built and tested
- First functional prototypes

Applications

- Permanent monitoring of bioprocesses
- Measurement throughout the entire volume
- Minimization of process influence using sensor technology

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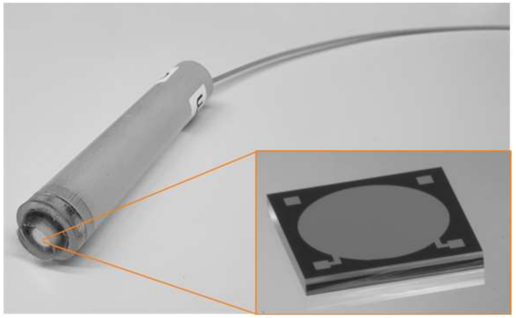
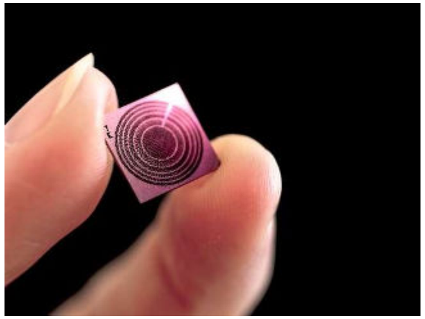
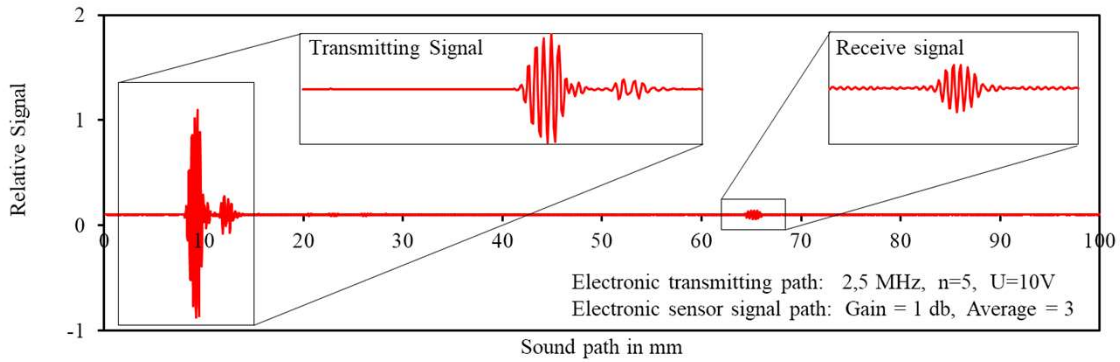
Micromechanical Ultrasonic Transducer



CMUT for NDT: sensor area: Ø 5 mm



Angular array PMUT (10x10 mm²)



Example of a time-of-flight detection of an object

General

- Micromechanical ultrasonic transducers with capacitive or piezoelectric operating principle
- Use as sensor and receiver
- Production of arrays for two-dimensional measurement of material properties and height profiles, object detection or level measurement

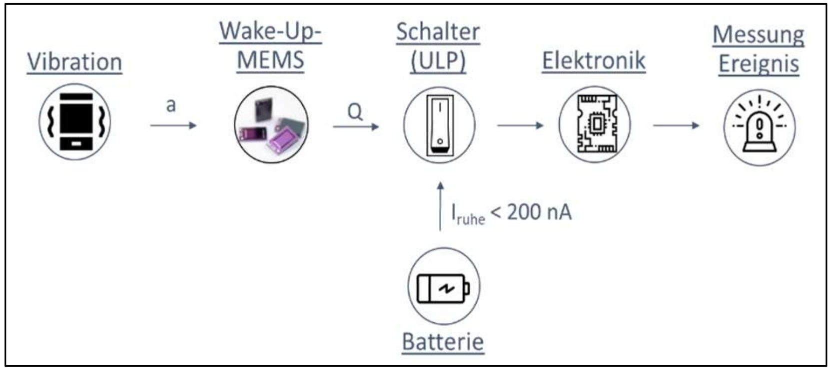
Benefits

- Piezoelectric elements in wafer level technology
- Evaluation electronics for liquid media
- System packaging, also for harsh environments

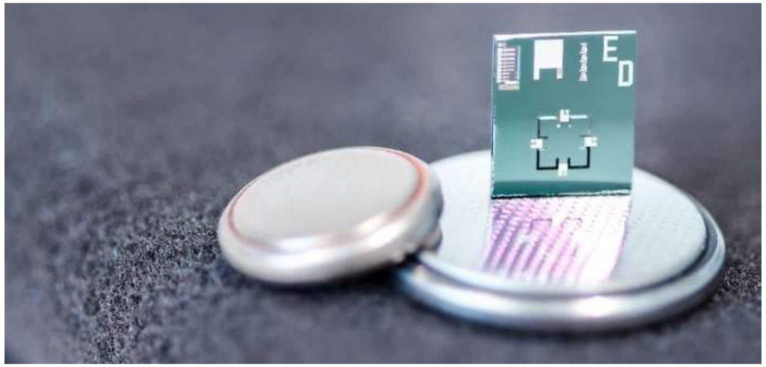
Applications

- Ultrasonic imaging of solid, liquid or gaseous media
- Mapping of height profiles, object recognition
- Medical image processing
- Non-destructive testing
- Flow measurement
- Level measurement

Wake-Up MEMS



Working principle Wake-Up MEMS



Wake-Up MEMS on top of a coin cell.

General

- Inertial sensor
- Intrinsic charge generation due to inertial signal from environment
- Battery free MEMS function with wake-up function
- Wake-Up MEMS wakes electronics from sleeping mode
- Development: Wake-Up signal is stored on nanoionic devices (complete battery free system)

Cooperation

University Bochum and more

Applications

- Near-Zero-Power inertial sensor
- Battery free Zero-Power inertia sensors (with nanoionic storage device)

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Sensors for health applications

- Stretchable and flexible substrates/systems are getting more and more important for wearables even direct on skin.

  Flexible electronics and sensors need smart power sources and energy storage as well as power management

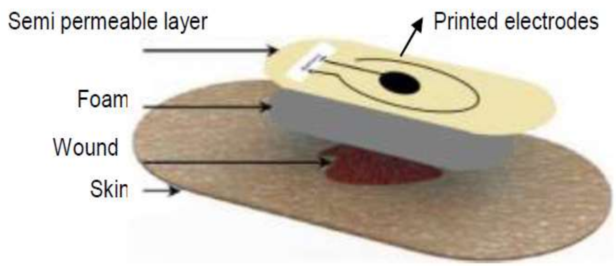
  Encapsulation and packaging technologies need optimized biocompatible integration.

  Examples:

Implantable Devices

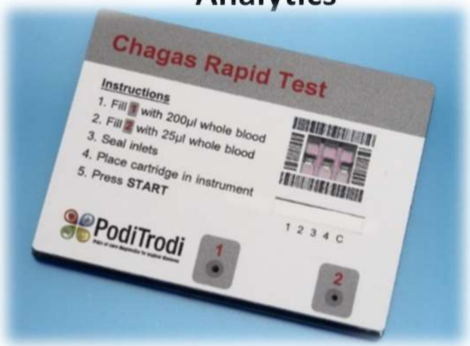
Demonstrator Hemodynamics
Highly miniaturized implant with pressure, temperature, and acceleration sensor as well as ASIC, inductive Link for wireless data and power transfer, LTCC

Medical Equipment



Active wound healing patch
Flexible Substrate, Interdigitated Electrodes
Energy supply, Skin Contact / Interface

Analytics



Demonstrator PodiTrodi
Micro fluidic plattform with integrated biosensors for DNA and protein analysis

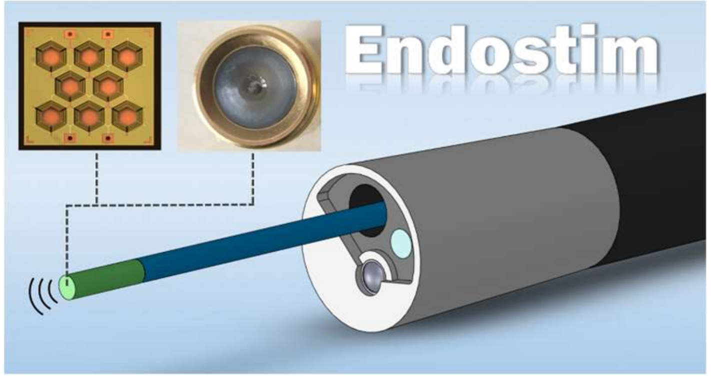
Biocompatible Endo-Equipment based on MOEMS

Implants and medical equipment

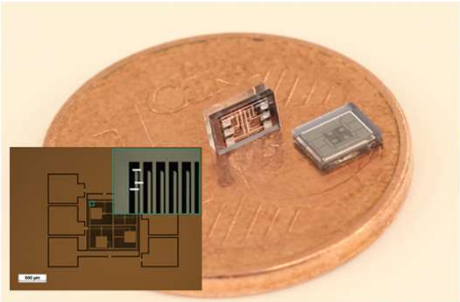
High precision MEMS, highly miniaturized and functionalized (incl. electronics)

Integration technologies for MEMS and electronics at temperatures below 200°C

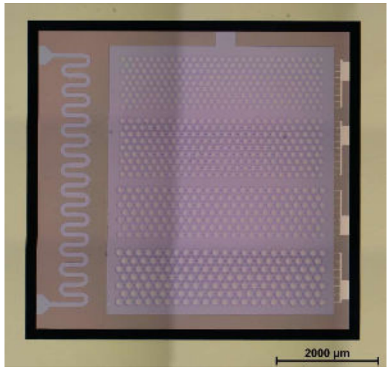
Biocompatible multi layer encapsulation



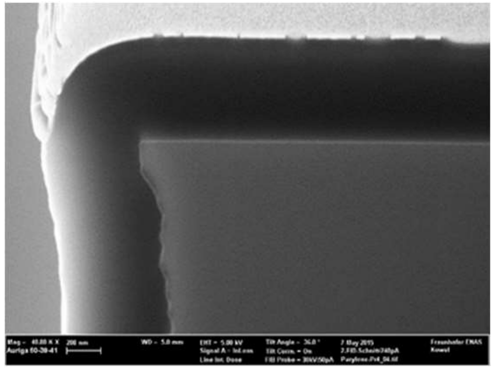
Project reference „Endostim“



2D & 2 ranges inertial sensor Si/Glass,
Ca. 1 x 1 mm² active sensor area



Ultra sonic transducer Si,
Ca. 6 x 6 mm²…3 x 3 mm²



Thin film encapsulation by using Parylene C, 600 nm thin

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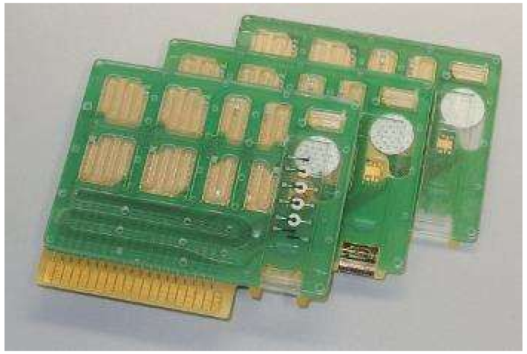
Lab on a Chip Systems



Microfluidic cartridges with integrated electro-chemical and optical sensors

Microfluidic cartridges for pathogen detection in chipcard technology

SARS-COV2-Test.

Mobile measuring device

General

- Electrochemical low-cost integrated actuation technology for pumps and valves
- Transfer of bio-chemical assays into microfluidic systems (incl. instrument)
- miniaturized detection of pathogens, vital parameters or (electro-)chemical properties

Benefits

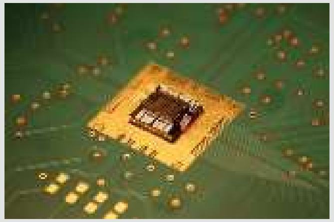
- High degree of automation
  → no skilled personnel necessary
- No fluidic interconnections necessary
  → low risk of contamination
  → robust

Applications

- Human and veterinary point of care diagnostics
- Environmental monitoring
- Food safety

Sensor and Actuator Systems

Inertial sensors

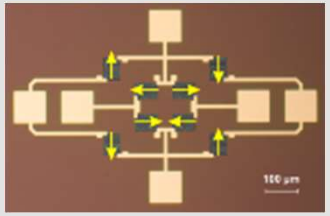


Sensors for
- Acceleration
- Vibration
- Inclination
- Yaw rate

Optics/MOEMS

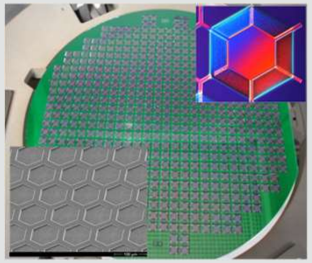
- Optical filter
- Optical grating
- Controllable detectors and sources
- Spectral sensors
- QD LED

Electromagnetic sensors



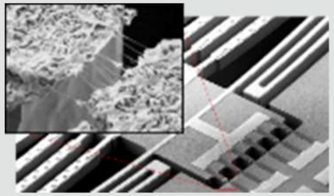
Sensors for
- Magnetic field
- Distance
- Position
- Rotation
- Characterization of electro-magnetic fields

Pressure and Force



- Ultrasonic devices
- MEMS loudspeaker
- Pressure sensitive resonators
- Pressure sensors
- Tactile sensors

Material and structure



Sensors for
- Mechanical stress
- Strain
- Overload
- Humidity
- Analysis of thermo-mechanical load

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