Highly miniaturized multi sensor system for biomedical applications

Chemnitzer Seminar 2017

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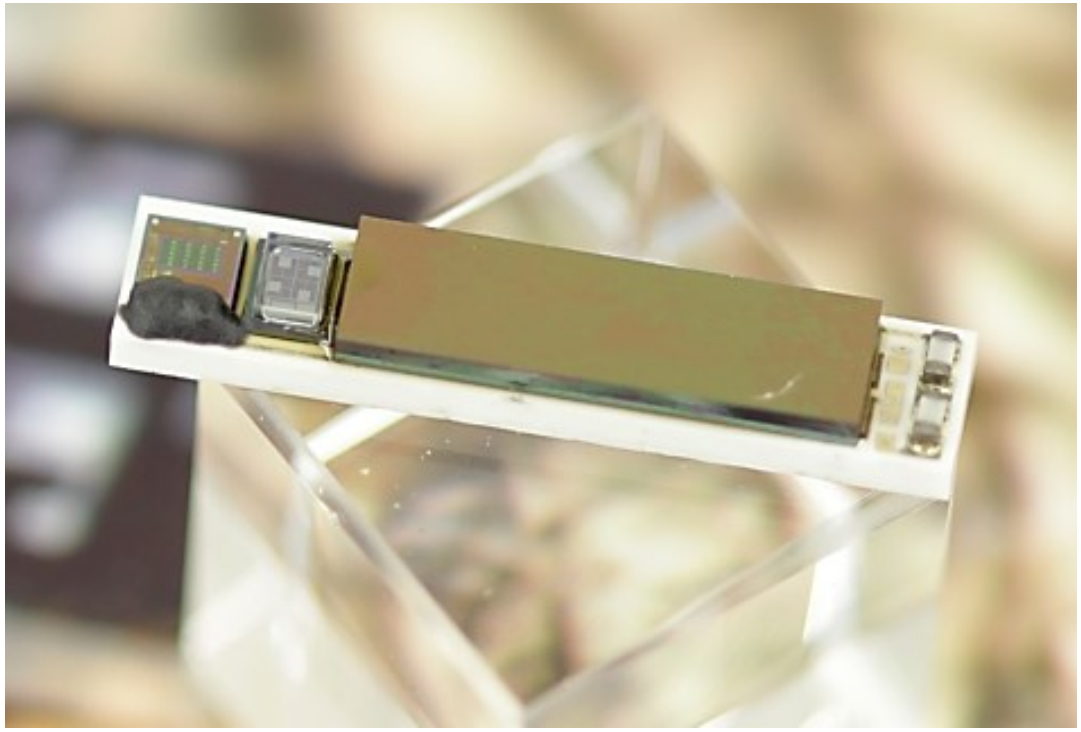
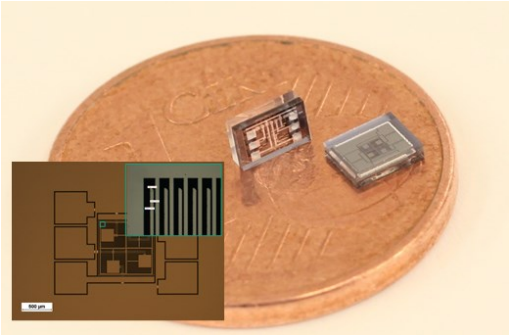


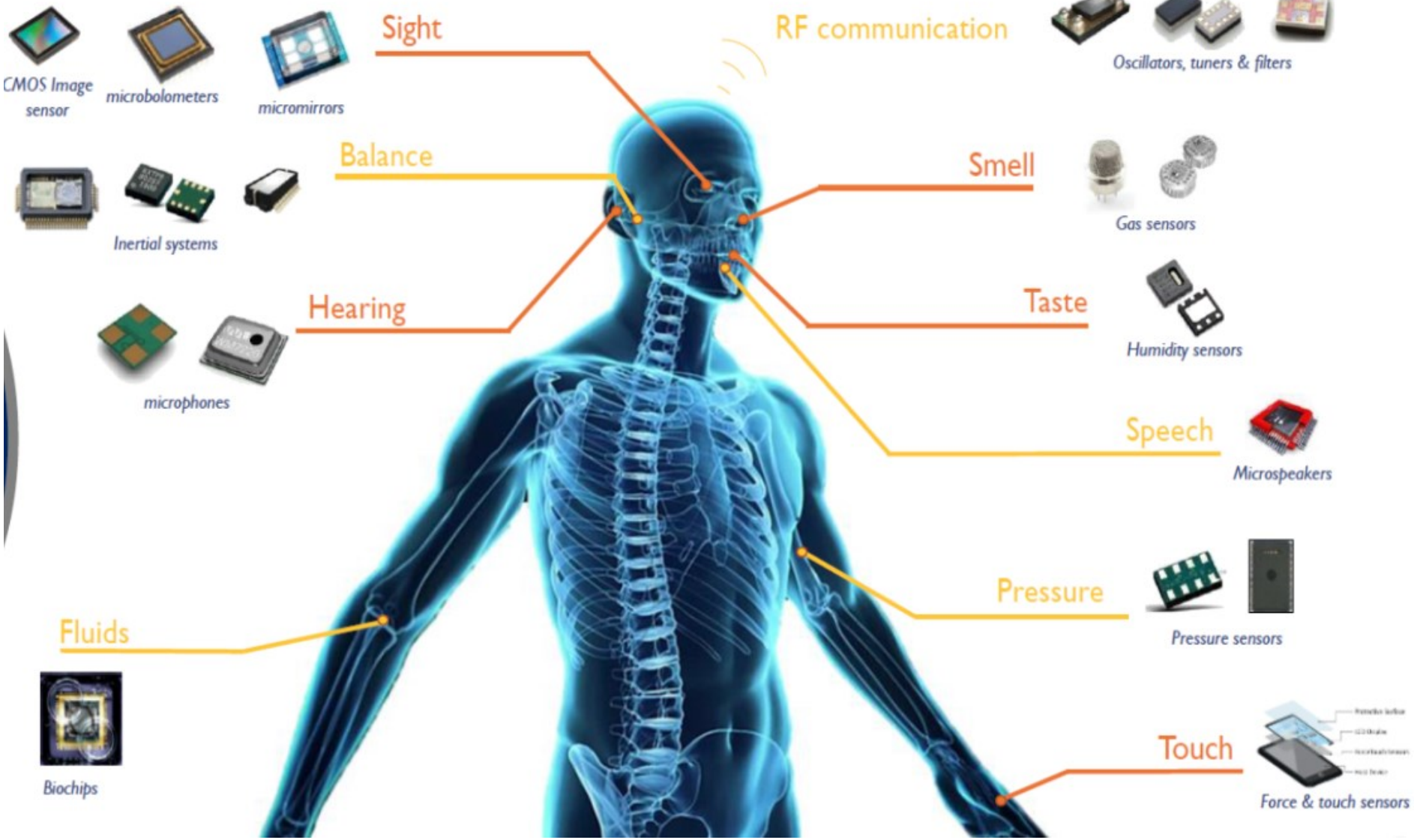
MEMS for medical applications

- Actual Si micro systems development and further miniaturization as well as functionalization lead to more and more application potentials in medical fields
  - Today's chip dimensions of inertial sensors are around 2mm² to 25mm².
  - The accuracy and lifetime of inertial sensors is impressive!
  - Well known: pressure sensors, optical sensors, electrodes
- Potential of Applications
  - Growth/a of medical device: ca. 20%

Source: Yole: „Sensors for Wearable Electronics and mobile Healthcare", 2015



MEMS for medical applications



Source: Yole: „Sensors for Wearable Electronics and mobile Healthcare“, 2015

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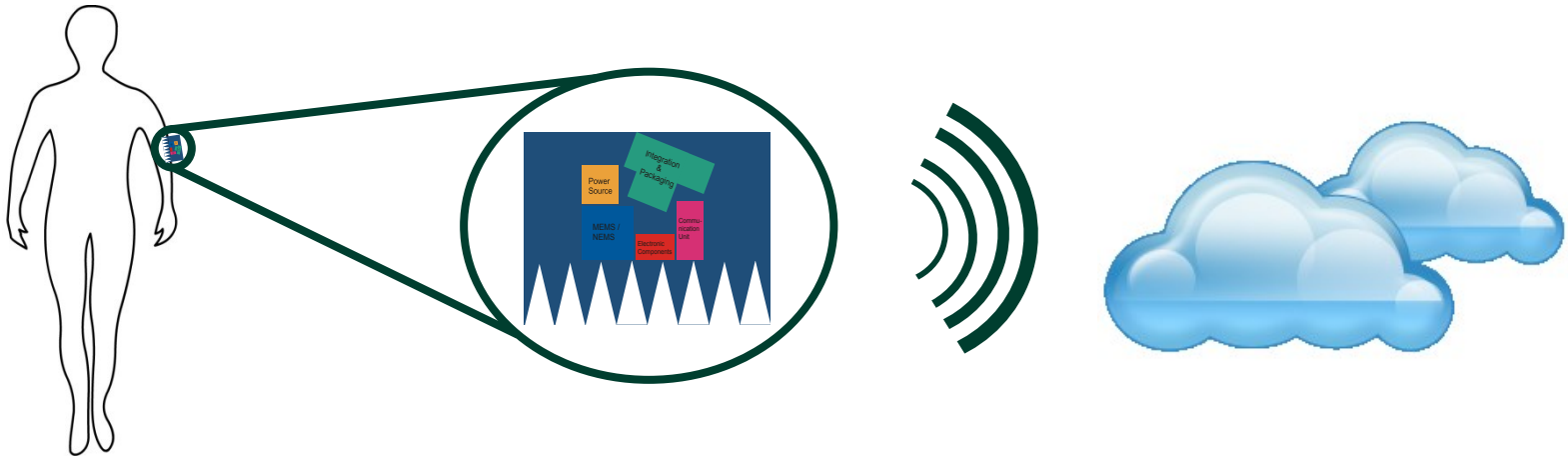
Perspective

- Medical engineering requires the cooperation of different disciplines
- Smart systems have a broad field of applications



Medical Parameters

- Physiological
- Biochemical
- Neurological

Smart Systems

- Integration
- System Packaging
- Energy Supply
- Communication
- Electronic Components

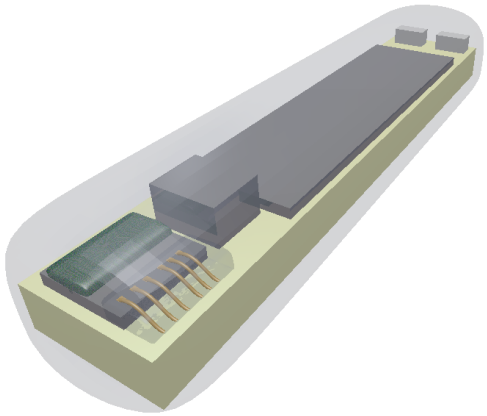
Cloud

- Data
- Data management
- Statistical approaches

Towards the INTERNET OF THINGS

Business Unit
Smart Medical Systems

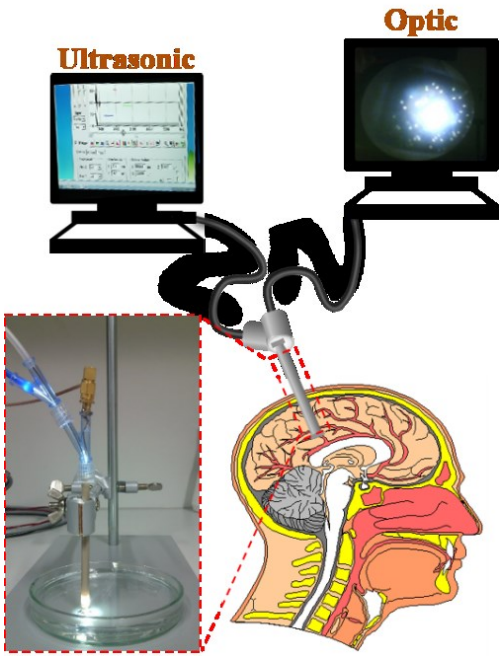
Implantable Devices



Demonstrator Hemodynamics

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

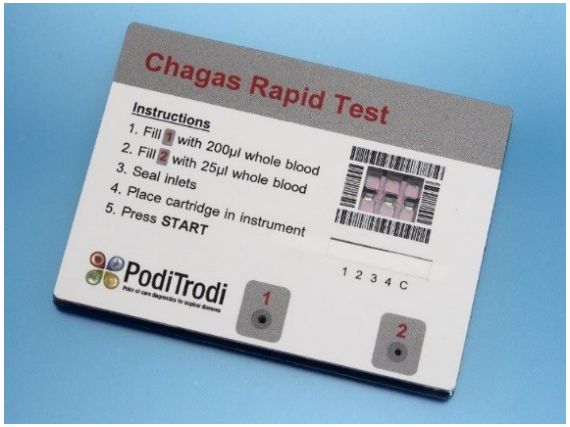
Medical Equipment



Demonstrator DeNeCoR

MR-compatible micro endoscope with Ultrasonic imaging and optical imaging

Analytics



Demonstrator PodiTrodi

Micro fluidic plattform with integrated biosensors for DNA and protein analysis

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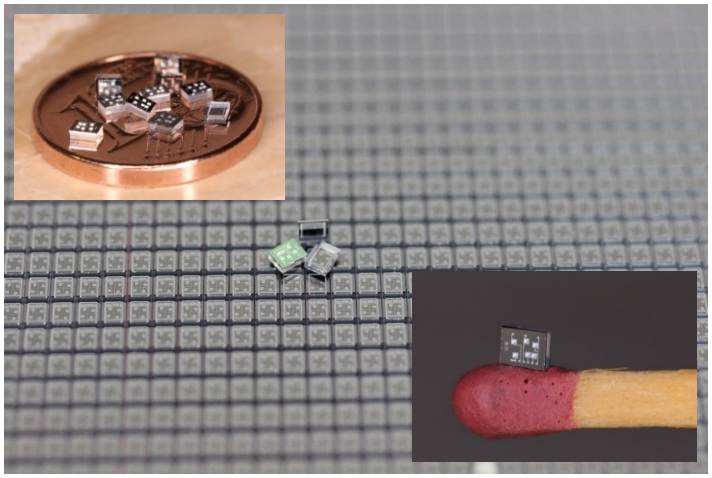
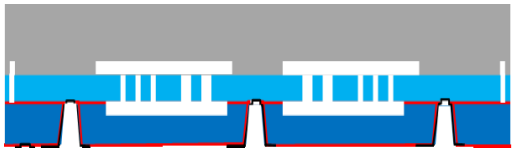
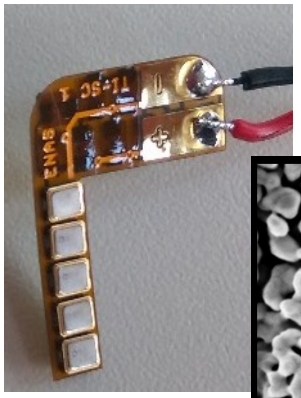
Project Example Theranostic Implants

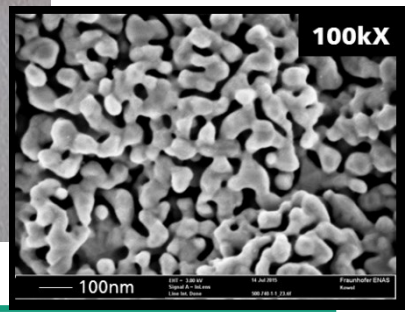
R&D Activities at ENAS



- **There are four main tasks within two subprojects**
  - Heart: Development of a miniaturized and implantable inertial sensor (ca. 1 mm x 1mm x 1mm)
  - Heart: Development of a biocompatible thin film packaging using e.g. ALD/Parylene
  - Heart: Development of a 3D integrated coil using LTCC multilayer ceramics
  - Hand: Development of a short term energy storage (SuperCap) using nano (CNT/NPM)







- **Biocompatibility needs certain materials, process integration**
  - Multilayer approach is investigated using Parylene and ALD Al2O3, 3D samples fabricated and covered successfully

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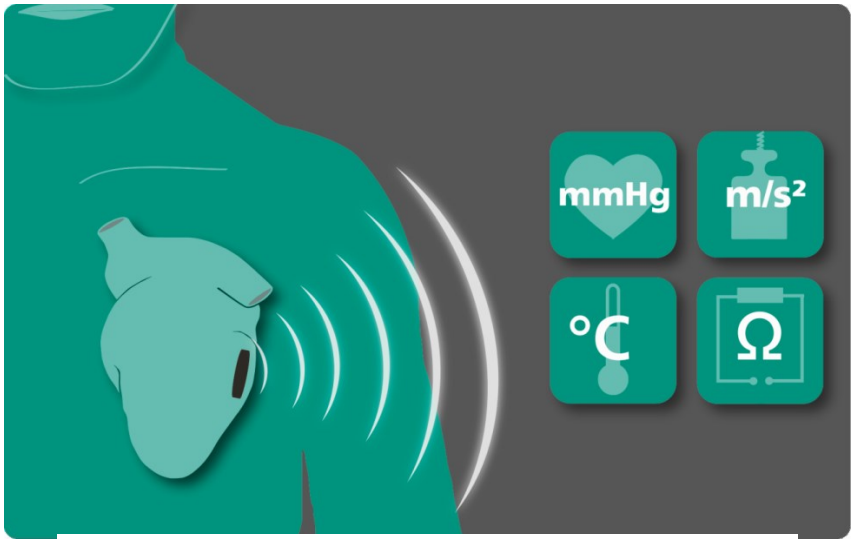
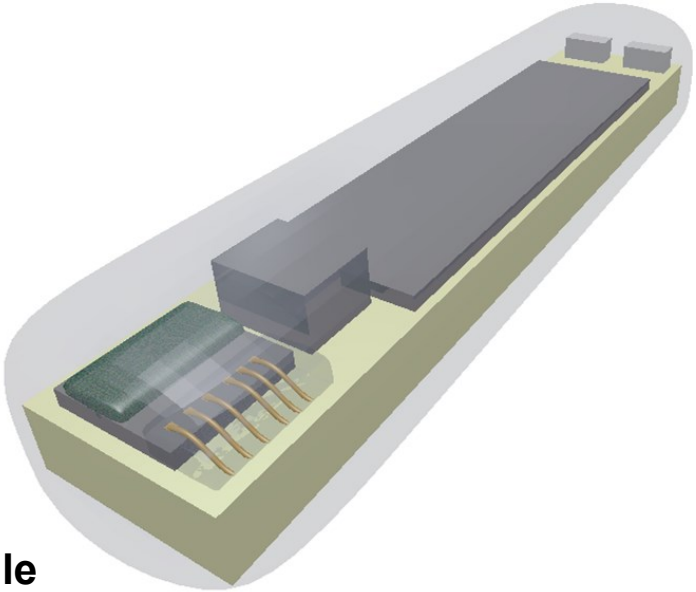
Introduction to the heart failure implant



Overall system for the hemodynamic controlling: external transmitter/reader and an implantable sensor unit

Im

Implantable sensor module: pressure, voltage, impedance, temperature and acceleration



Overall size: 3.5 x 15.5 mm²

ceramic interposer module

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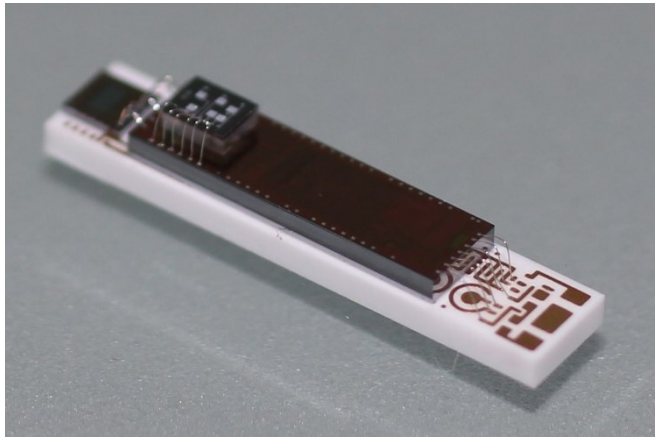
Experiments and results
Packaging



Wire Bond Demonstrator

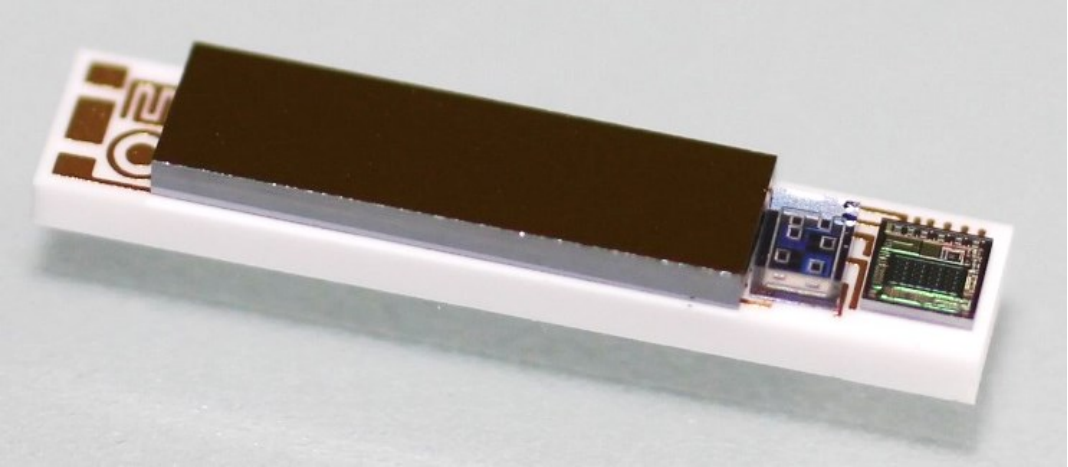
Soldering of passive components

Wire bonding of the pressure sensor

Flipchip bonding of the ASIC and the accelerometer

Hermetic encapsulation of the whole system

- Parylene C (2 x 1 µm)
- ALD (50 nm)
- Parylene C (2 x 1 µm)



Assembled system consisting of pressure sensor, acceleration sensor and ASIC

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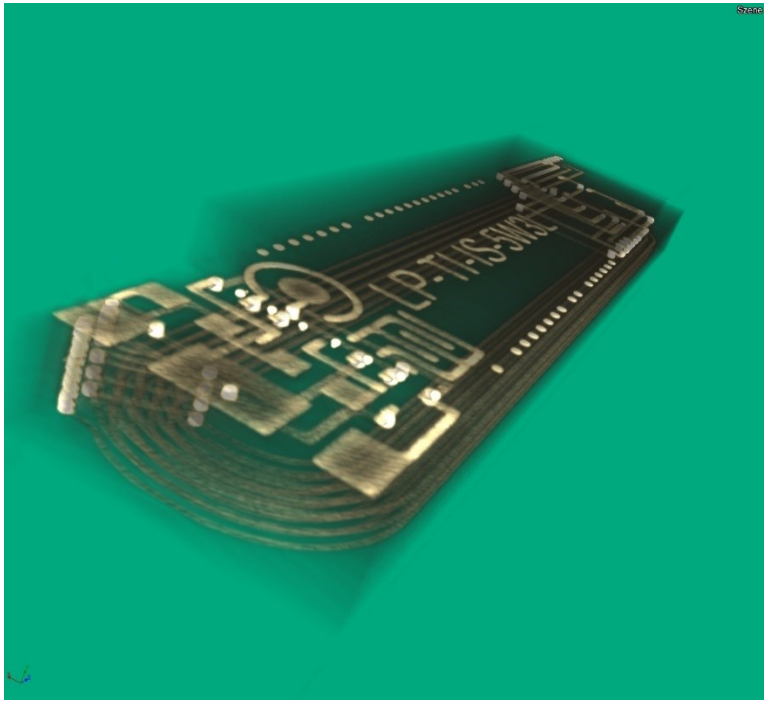
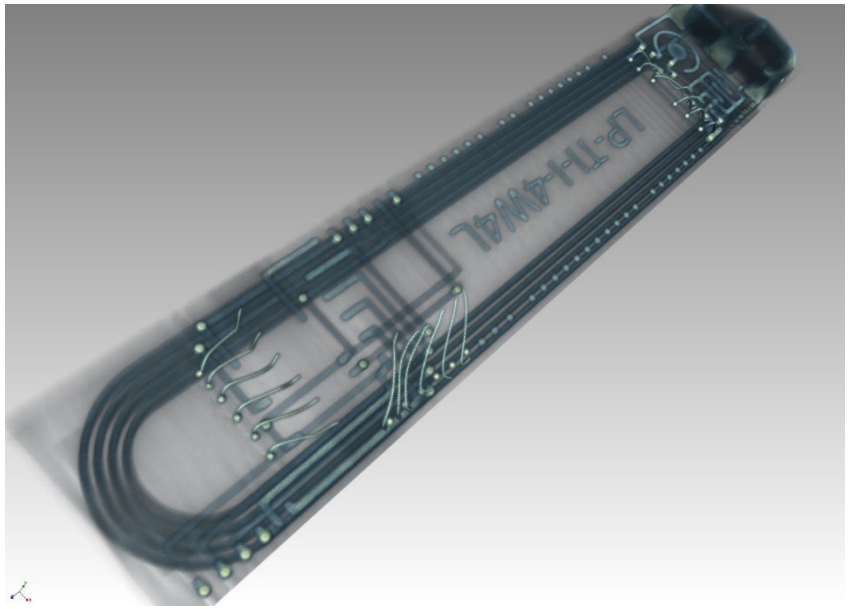
Experiments and results
Characterization

- **X-Ray CT Analysis**
  - Non destructive
  - Shows bond failures even after encapsulation



CT-Analysis of the stud bump FC bonded demonstrator



CT-Analysis of the wire bonded demonstrator

Experiments and results
Summary of Project example

Highly miniaturized acceleration sensor

- Core size: 1.0x1.0mm², overall size: 1.5x1.2mm²
- Two approaches of BDRIE fabrication technology successfully tested
- Fabricated MEMS characterized in terms of capacity, natural frequency and sensitivity

Packaging could fulfill the requirements

- LTCC multilayer interposer technology, overall size: 3.5 x 15.5 mm² after encapsulation
- Au stud bump - based thermosonic flip chip bonding
- Au wire bonding

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Conclusion

- **High performance MEMS will generate a high potential for medical applications**
- **Patient specific or application specific MEMS have to fulfil cost expectations! Even as a niche…**
- **Stress free and low temperature bonding technologies will be necessary for stress reduced sensor performance**
- **Encapsulation and packaging technologies will need further optimization regarding biocompatible integration!**
- **Call to Action:**
  - **We need ideas for integration of sensors into implants!**
  - **We want to decrease the size of future implants!**
  - **Open your mind and share your needs!**

Thank you!

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