Highly miniaturized multi sensor system for biomedical applications

Chemnitzer Seminar 2017

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%

MEMS for medical applications

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**

<table>
<thead>
<tr>
<th>Implantable Devices</th>
<th>Medical Equipment</th>
<th>Analytics</th>
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<tbody>
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<td><img src="image" alt="Implantable Devices Diagram" /></td>
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**Demonstrator Hemodynamics**

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

**Demonstrator DeNeCoR**

MR-compatible micro endoscope with Ultrasonic imaging and optical imaging

**Demonstrator PodiTrodi**

Micro fluidic platform with integrated biosensors for DNA and protein analysis
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
Introduction to the heart failure implant

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

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

Overall size: 3.5 x 15.5 mm²
Experiments and results

Packaging

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)
Experiments and results

Characterization

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

CT-Analysis of the wire bonded demonstrator

CT-Analysis of the stud bump FC bonded demonstrator
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
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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