Micro and Nano Technologies for Smart Health and personalized Medicine

Business Unit Smart Health

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General Trends in Health and Medical Technology

- **Computerization:**
  - Software and Algorithms
  - Artificial Intelligence for Data Evaluation
  - Digitization

- **Individualization:**
  - Personalized Medicine
  - Precise drugs and treatments
  - Individual implants and prosthetics (3D printing)

- **Molecularization:**
  - Point-of-Care diagnostics (Proteins, DNA, RNA analytics)
  - Organ-on-Chip
  - Imaging

- **Miniaturation:**
  - Implants
  - Wearables
  - Nano

- **Mobile Health:**
  - Remote support at home
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
  → dimensions less than the thickness of human hair

Why MEMS for sensors?
- Smaller in size
- Cheaper due to mass production
- More sensitive to input variations
- Have lower power consumption
- Less invasive than larger devices
Status of MEMS for medical applications

Source: Yole: „Artificial Intelligence for Medical Imaging 2020“
Example: Highly miniaturised implant with pressure, temperature, and acceleration sensor, ASIC, inductive link for wireless data and power transfer, LTCC

Example: MR-compatible micro endoscope with Ultrasonic imaging and optical imaging, CMUT on an endoscope for therapeutic treatment of tissue.

Example: FPI MOEMS chip for optical and spectral analysis and micro fluidic platform with integrated biosensors for DNA, RNA, and protein analysis
Innovation examples

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

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
Project example: EndoStim – CMUT on Endoscope

Introduction

<table>
<thead>
<tr>
<th>Market</th>
<th>Players</th>
<th>Applications</th>
</tr>
</thead>
<tbody>
<tr>
<td>CMUT market is rapidly expanding.</td>
<td>Research</td>
<td>• Medical Imaging</td>
</tr>
<tr>
<td>Medical imaging remains the main applications.</td>
<td>• Stanford University, Fraunhofer, Imec, University of Rome, ...</td>
<td>• Medical therapy</td>
</tr>
<tr>
<td></td>
<td>• Industry</td>
<td>• Photoacoustic imaging</td>
</tr>
<tr>
<td></td>
<td>• Hitachi, Butterfly Network, Philips, Kolo, Vermon</td>
<td>• Gas flow sensors</td>
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<tr>
<td></td>
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<td>• Acoustic actuator / manipulator</td>
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<td>• Non destructive testing</td>
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CMUT - State of the Art in Medical Applications

Dominated by medical imaging
- Endoscopy, Probe or Catheter based

Butterfly Network
- First handheld CMUT probe
- Battery operated
- Connected to smartphone

Multi-tasking 4G CMUT linear matrix probe by Hitachi

High frequency probes by Kolo
CMUT - Development Flow @ ENAS

1. Material selection
2. Simulation
3. Extract device geometry
4. Fabrication
5. Layout & Mask design
6. Assembly, packaging and characterization
## Research and Development on CMUT - Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Specification</th>
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<tbody>
<tr>
<td>Fabrication Technology</td>
<td>Wafer Bonding</td>
</tr>
<tr>
<td>Wafer size</td>
<td>6” (also possible in 8”)</td>
</tr>
<tr>
<td>Number of die per wafer</td>
<td>Layout and wafer size dependent (e.g. 1000)</td>
</tr>
<tr>
<td>Number of elements per die, and CMUT cell in each die</td>
<td>Application dependent</td>
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<tr>
<td>CMUT cell diameter</td>
<td>10-500µm</td>
</tr>
<tr>
<td>Membrane thickness</td>
<td>Up to 10µm</td>
</tr>
<tr>
<td>Cavity depth</td>
<td>Design dependent e.g. from below 1µm to 3µm</td>
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<tr>
<td>DC bias voltage</td>
<td>Up to 150V</td>
</tr>
<tr>
<td>AC excitation voltage</td>
<td>Up to 150V</td>
</tr>
<tr>
<td>Frequency range</td>
<td>Design dependent e.g. from below 1 MHz up to 15 MHz</td>
</tr>
<tr>
<td>Acoustic power</td>
<td>Design dependent Starting in kPa ranges</td>
</tr>
</tbody>
</table>
Conclusion

- High performance MEMS will generate a high potential for medical applications, especially as a „system“

- Patient specific or application specific MEMS have to fulfill cost expectations and medical reimbursement needs! Even as a niche…

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

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

- Encapsulation and packaging technologies will need further optimization regarding biocompatible integration!

- Research for medical products need strategic initial and preparatory activities in close cooperation with manufacturers.
Thank you!

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