Moore4Medical
WP4
Next generation ultrasound

Work package leader:

Vincent Henneken

Moore4Medical

TUE – Eindhoven University of Technology

Shivraj Karewar
Postdoctoral researcher

Johan Hoefnagels
Associate professor

Olaf van der Sluis
Full professor

Jaap den Toonder (WP2)
Full professor

Building Gemini at the Eindhoven University of Technology campus, housing of the state-of-the-art Microfab/lab and the Multiscale lab.

TU/e EINDHOVEN UNIVERSITY OF TECHNOLOGY

Moore4Medical

TUE

- University, concept creation. Two research units are involved:
  - Microsystems (MS) – WP2
  - Mechanics of Materials (MoM) – WP4

Mechanics of Materials
- Thin films mechanics, multi-scale mechanics
- Numerical methods: nonlinear finite elements, discrete particle simulations such as Molecular Dynamics
- https://www.tue.nl/en/research/research-groups/mechanics-of-materials/

Microsystems
- tbd

Moore4Medical
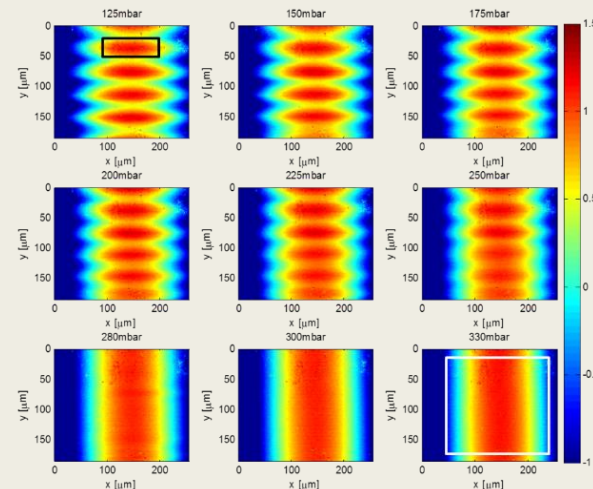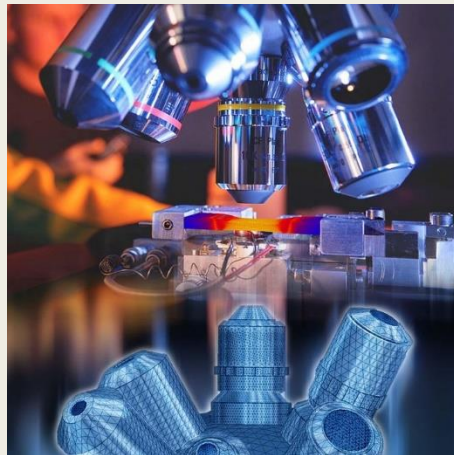
TUE contribution WP4

MoM section:
- T4.2: Prediction of residual stresses in low-frequency CMUTs based on discrete particle simulations of thin film deposition processes. This is especially critical for low frequency CMUTs where the membranes are very large and suspending very small gap. The simulations will be performed by discrete particle techniques, such as molecular dynamics.
- Partners: PEN, TUD
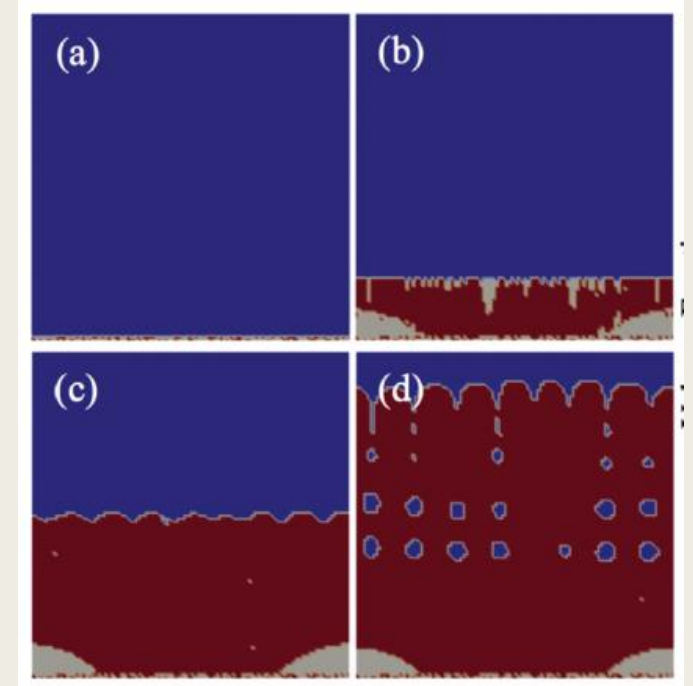
Example of simulation of PVD deposition process (Stewart & Spearot, 2018)

Moore4Medical
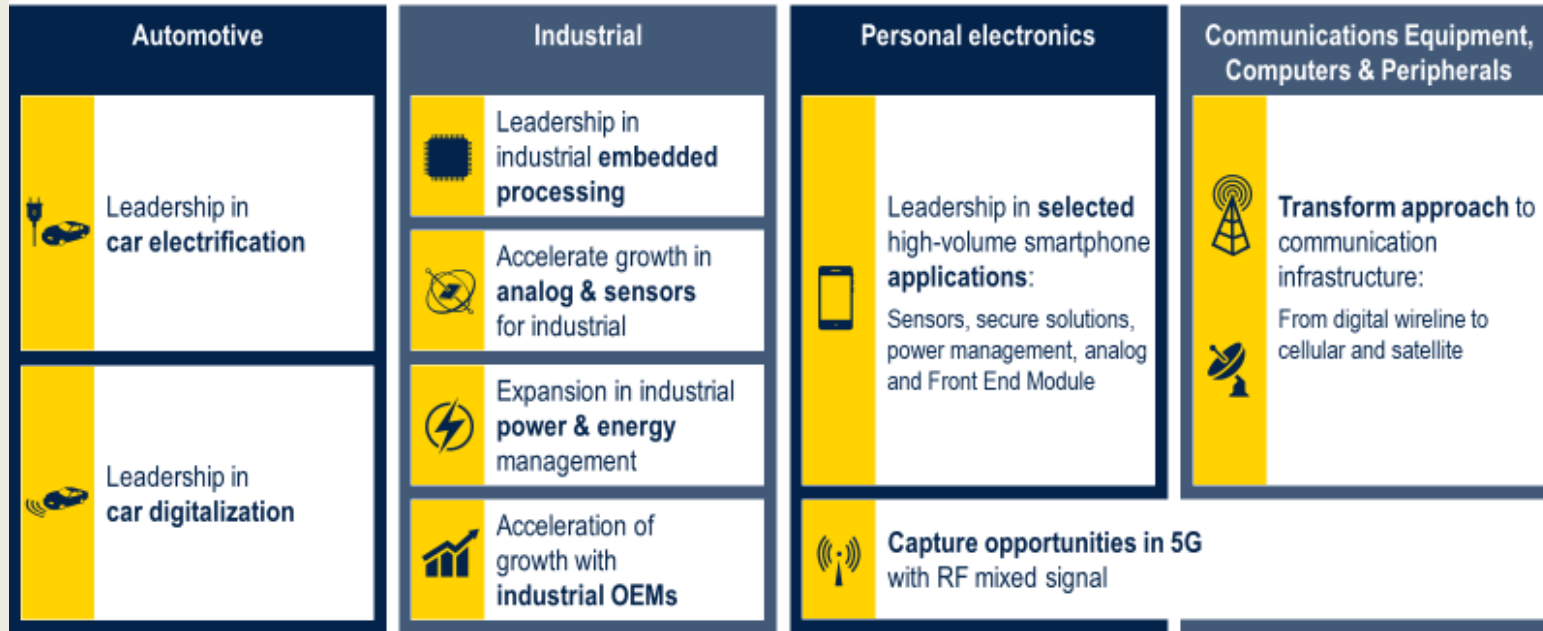
STMicroelectronics key contacts

Fabio Quaglia

ST project leader

Andrea di Matteo

ST project coordinator

ST Milan - The home of MEMS

STMicroelectronics is one of the world's largest semiconductor companies with net revenues of US$ 9.56 billion in 2019, with a operating margin of 38.7 % and a net income of US$ 1.03 billion. Offering one of the industry's broadest product portfolios, ST serves customers across the spectrum of electronics applications with innovative semiconductor solutions by leveraging its vast array of technologies, design expertise and combination of intellectual property portfolio, strategic partnerships and manufacturing strength.

Moore4Medical

STMicroeletronics

Our strategic objectives

Automotive
- Leadership in **car electrification**
- Leadership in **car digitalization**

Industrial
- Leadership in industrial **embedded processing**
- Accelerate growth in **analog & sensors** for industrial
- Expansion in industrial **power & energy** management
- Acceleration of growth with **industrial OEMs**

Personal electronics
- Leadership in **selected** high-volume smartphone **applications**: Sensors, secure solutions, power management, analog and Front End Module
- **Capture opportunities in 5G** with RF mixed signal

Communications Equipment, Computers & Peripherals
- **Transform approach** to communication infrastructure: From digital wireline to cellular and satellite

16

ST-I R&D infrastructures includes:
- Si process technology laboratories in Agrate Brianza (MB) / Cornaredo (MI), fully equipped with simulation tools and equipments for on wafer and in package device characterization and testing and for physical analyses
- Packaging technology laboratories in Agrate Brianza (MB), equipped with simulation and testing tools
- Integrated circuits design and verification tools
- Laboratories for electronic system development, characterization and testing
- Tools for algorithms development in electronic systems

1. ENIAC KET 2012: LAB4MEMS "LAB FAB for smart sensors and actuators MEMS"
2. ENIAC KET 2013: LAB4MEMS II "Micro-Optical MEMS, micro-mirrors and picoprojectors"
3. H2020 ICT-03-2016: INSPEX "Integrated Smart Spatial Exploration System".
4. H2020 ECSEL IA Project Arrowhead-Tools H2020 ECSEL IA Project 826452, 2018.
5. ENIAC Call 2012-1 DeNeCor "Devices for NeuroControl and NeuroRehabilitation"

Moore4Medical

STMicroelecronics contribution into WP4

- PMUT technology and process flow definition

- PMUT wafer micro-fabrication

- PMUT electro-mechanical test (Impedance spectroscopy, Laser Doppler Vibrometer)

- ASIC design and realization (BCD or CMOS technology)

- PMUT and ASIC dice assembly: electronic device packaging

Moore4Medical

# MSD Laboratory –University of Florence (UniFI)

Piero Tortoli
UniFi unit leader
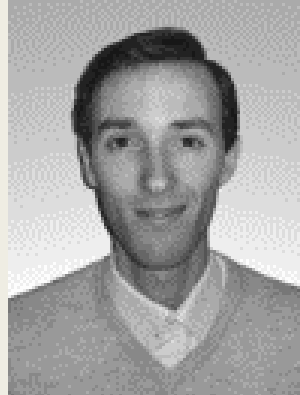
Enrico Boni
Design group leader

The Microelectronics Sytems Design (MSD) Laboratory is located in the School of Engineering, on the top of a hill looking at Florence

Moore4Medical

MSD Lab capabilities in M4M

- Biomedical systems design and implementation

- Custom ultrasound systems development

- Ultrasound open scanner development

- Development of innovative Imaging and Doppler methods

- Development of innovative ultrasound probes
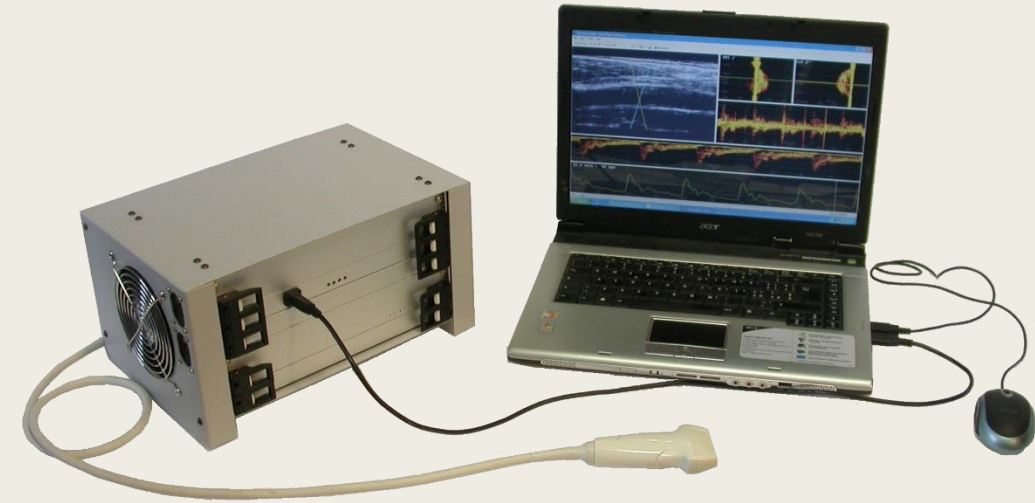
ULA-OP: 64-channel open scanner
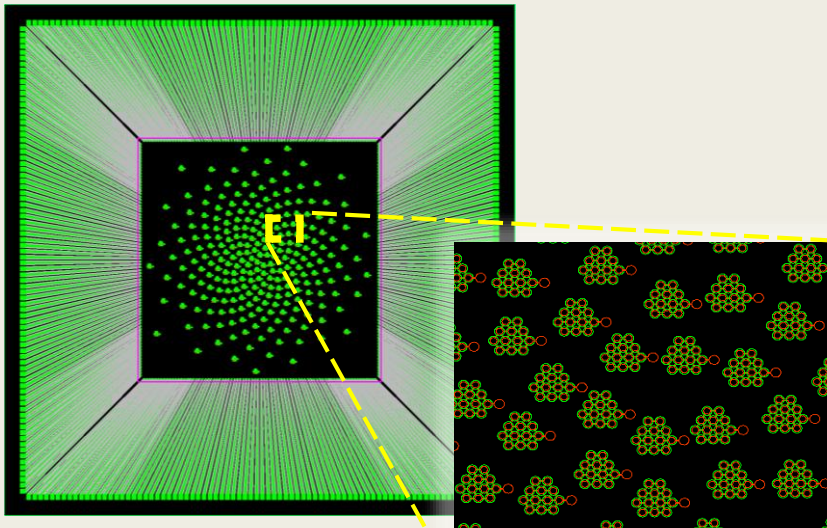
CMUT 2D-spiral array probe

Moore4Medical

UniFI planned contribution

UniFI will contribute to the design of:

- PMUT transducer arrays (functionality, geometry, n. of elements, center frequency, pitch and other relevant parameters)
- ASIC front-end

UniFI will develop a special version of ULA-OP 256 (256-channel open platform) capable of driving the new M4M PMUT arrays

We'll mostly work together with:

- STMicroelectronics
- University of RomaTRE
- University of Pavia

But we look forward to new partners!

Moore4Medical

University of Pavia (UniPV)

Andrea Mazzanti
Professor

Piero Malcovati
Professor

Edoardo Bonizzoni
Professor

Lara Novaresi
Research Grant

UNIVERSITÀ
DI PAVIA

The **University of Pavia** (UniPV) is one of the oldest in Europe, founded in 825. Many renowned humanists and scientists studied and taught at the Alma Ticinensis Universitas, such as Cardano, the inventor of the Cardanic joint, and Alessandro Volta, the inventor of electric battery. Nowadays, the multidisciplinary University of Pavia includes nine faculties with more than one thousand professors, three campuses and hosts more than 20 thousand students.

Moore4Medical

Department of Electrical, Computer and Biomedical Engineering

- 80 professors with internationally recognized scientific profile
- Research fields: **microelectronics**, industrial engineering,
- bioengineering and computer science
- 30 research labs, supported by public and private funding
- Tight relation with microelectronics companies
- Studio di Microelectronica: a joint lab between UniPV and STM

- **Research staff in microelectronics:**
  - 11 Professors, 5 Post-Doc Researchers, 18 Ph. D. Students

- **Research topics in microelectronics:**
  - Analog and mixed-signal integrated circuits
  - Integrated sensors, microsystems, and MEMS
  - Data converters
  - RF and mm-wave integrated circuits
  - Energy harvesting and power management
  - Non-volatile memories

Moore4Medical

UniPV Contributions into M4M: WP4

PMUT-based active probe for ultrasound imaging

- Contribution to spec definition

- Design and electrical testing of the front-end TX/RX channel for linear PMUT array

- Design and electrical testing of the front-end TX/RX channel for 2D-PMUT array
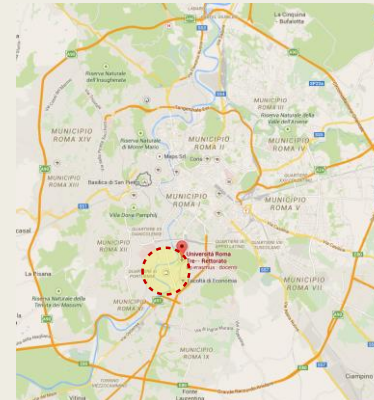
- Contribution to tests on demonstrators

Moore4Medical

UNIROMA3 - Who is who and where

Alessandro Stuart Savoia
UNIROMA3 Unit Leader

Alessandro Neri
Head of Applied Electronics Section

Roma Tre University
Roma, Italy

Department of Engineering
Applied Electronics Section

Acousto-Electronics Lab
(ACULAB)

Moore4Medical

UNIROMA3 – our capabilities

20-Year Experience on **Micromachined Ultrasonic Transducer** Development: from Design to System Integration

- MEMS ultrasonic transducer Design
- FEM and system-level modeling
- Microfabrication and packaging
- Acoustic materials
- Characterization
- Electronic front-end circuit design
- Probe development
- Ultrasound imaging system integration

- **1998** MUT research started
  - **1999** Single-element CMUT transducer
    - **2003** 64-element 1D probe
      First ultrasound imaging on clinical scanner
      - **2004** 128-element 1D probe with embedded electronics
        - **2007** 192-element 1D probe
          Reverse Fabrication Process
          - **2009** High frequency 192-element 1D probe
            - **2015** 256-element 1D probe
              - **2016** 120+120-element 2D row-column probe
                - **2018** 256-element 2D array with ASIC AFE

Moore4Medical
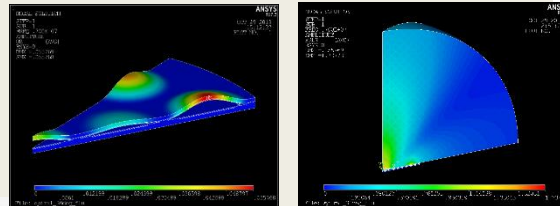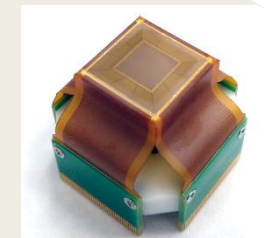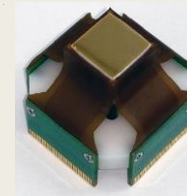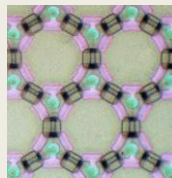
UNIROMA3 – our planned contribution to WP4

UNIROMA3 will contribute to:

- PMUT transducer 1D and 2D array design (FEM for microstructure design and system-level modeling for electronics front-end/transducer co-design)

- Transducer packaging (definition of interconnection and encapsulation strategies)

- Transducer/electronics characterization (electro-mechanical, acoustic)

- ASIC design

- Probe development (design and assembly)

UNIROMA3 will mostly work together with:

- Philips

- STMicroelectronics

- University of Florence

- University of Pavia

- …

Moore4Medical

Technische Universität Wien (TU Wien)

Radu Grosu
Head of Cyber-Physical
Systems Group

Muhammad Shafique
Head of Computer Architecture
and Robust Energy-Efficient
Technologies Group

Bharath Srinivas Prabakaran
PhD Researcher

Research Interests:
Prof. Dipl.-Ing. Radu Grosu: Computational Models in Systems Biology, Machine Learning, Model-based Design, Logic and Automata Theory, Applications of Machine Learning
Prof. Dr.-Ing. Muhammad Shafique: Applications of machine learning, HW/SW optimizations for ML Systems, Neuromorphic Computing, HW Architectures for ML

Moore4Medical

Research @ CPS

❑ **Smart Mobility**

 ❑ Neural Regulatory Networks

 ❑ Lane Tracking

❑ **Smart Farming**

❑ **Smart Healthcare**

❑ **Machine Learning**

❑ **Industry 4.0**

Moore4Medical
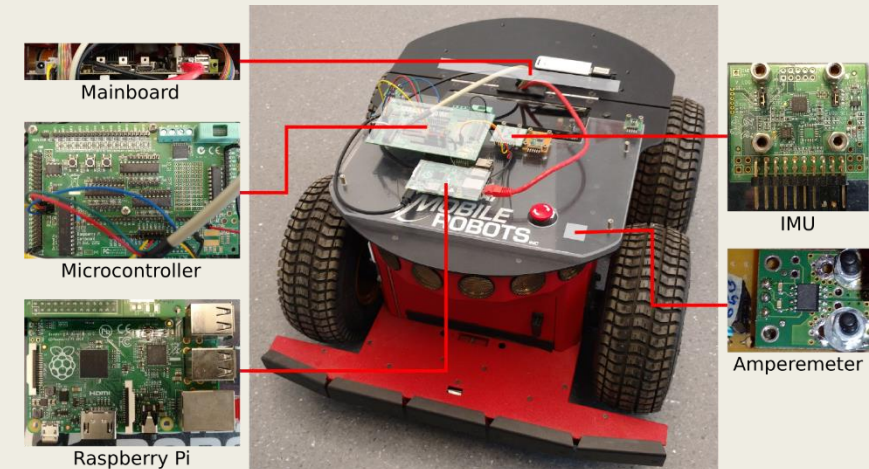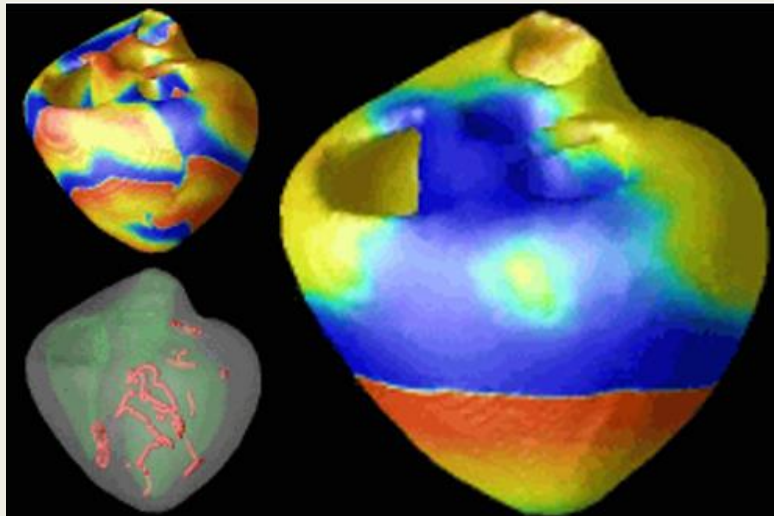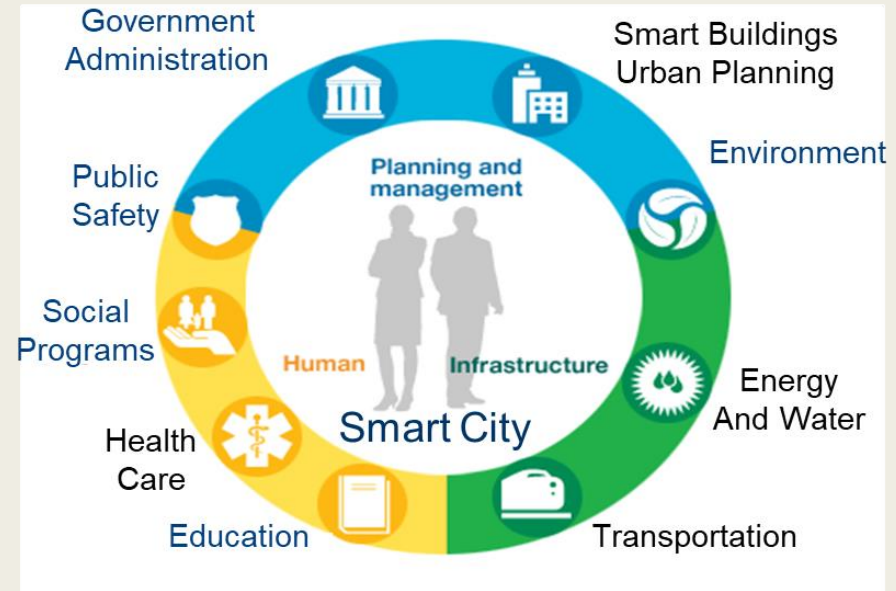
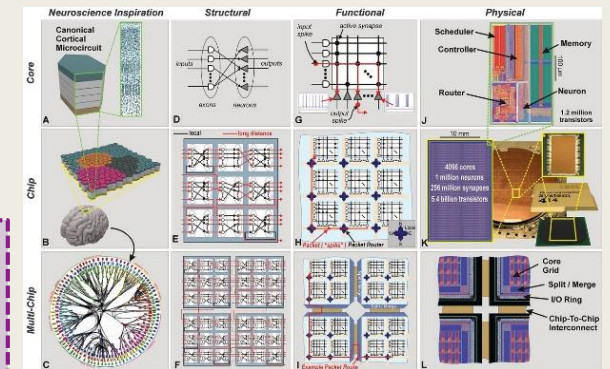# Research @ CARE-Tech

❏ **Brain-Inspired Computing**
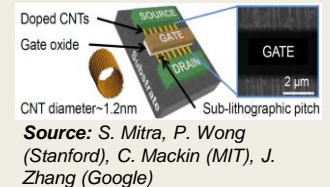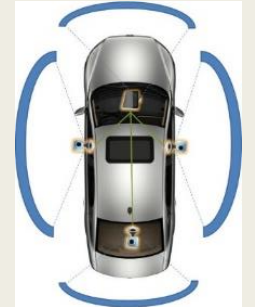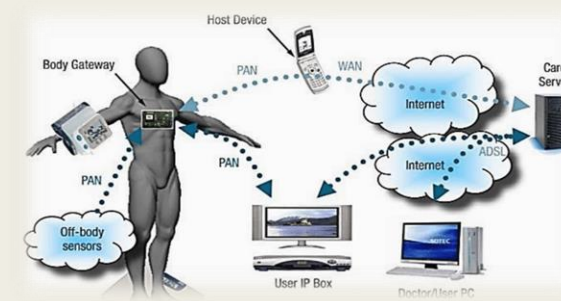
   ❏ Deep Learning, Neuromorphic Systems

   ❏ Post-CMOS technologies
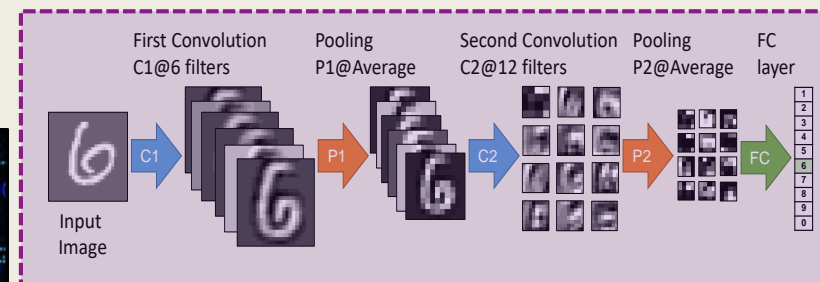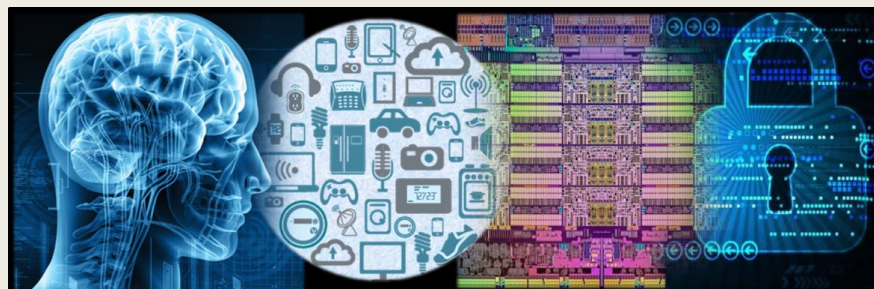
❏ **Low-Power** sensor-processing for CPS/IoT

   ❏ *In-memory computing*, near-sensor processing

❏ On-Chips Systems for **Smart Wearable Healthcare**

❏ **Robust** embedded machine learning

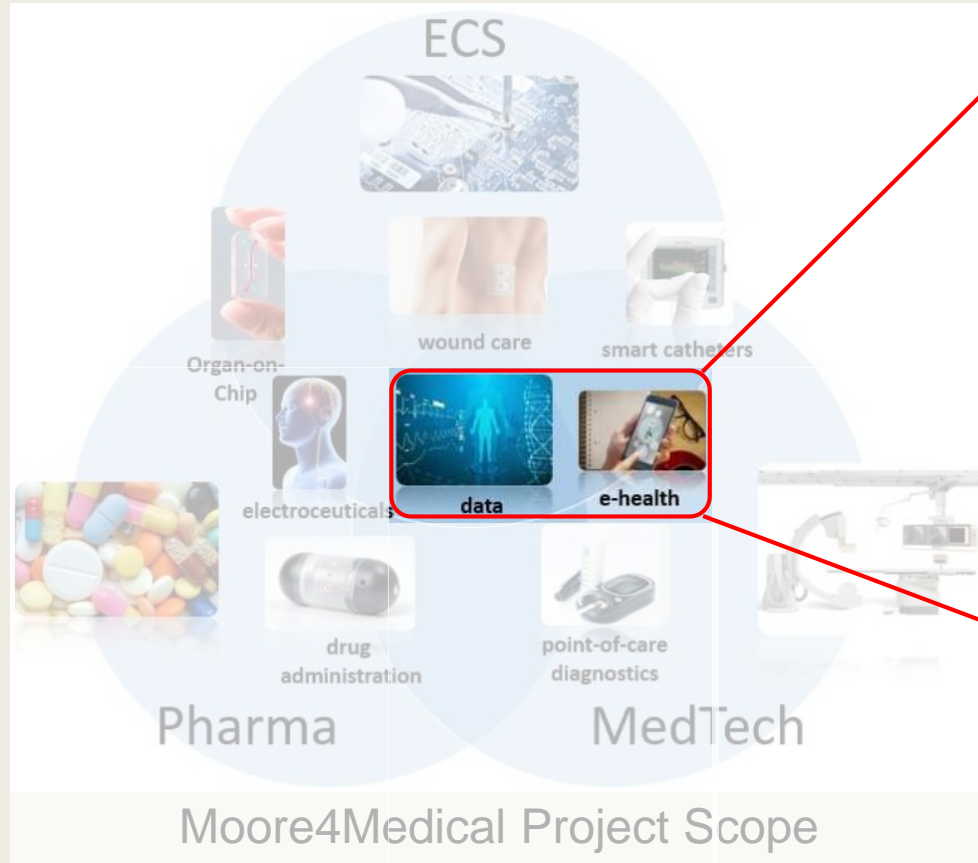   ❏ Reliability & Security of ML Systems

Source: S. Mitra, P. Wong (Stanford), C. Mackin (MIT), J. Zhang (Google)

Source: IBM, TrueNorth Chip

First Convolution C1@6 filters | Pooling P1@Average | Second Convolution C2@12 filters | Pooling P2@Average | FC layer

Input Image

Moore4Medical

TU Wien Planned Contributions

Moore4Medical Project Scope

Next Generation Ultrasound

- Data Acquisition
- 3D Reconstruction
- Edge Processing

- AI algorithms for detecting fetus' anatomical features
- Hardware accelerator for high throughput feature extraction
- Closed-loop system for real-time user feedback

Collaborators & Partners:

Moore4Medical