# Landscape of HSI and packaging research in NLuniversities

**Prof. G.Q. Zhang**

**Prof. Willem van Driel**

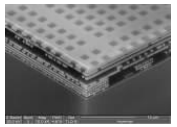
**Willem.vanDriel@tudelft.nl**

**g.q.zhang@tudelft.nl**

TU Delft

# Centre of any system creation

**Functional Devices**



- RF
- ICs
- LED
- Sensor
- MEMS
- Power
- Control
- Actuation
- Qubit
- …

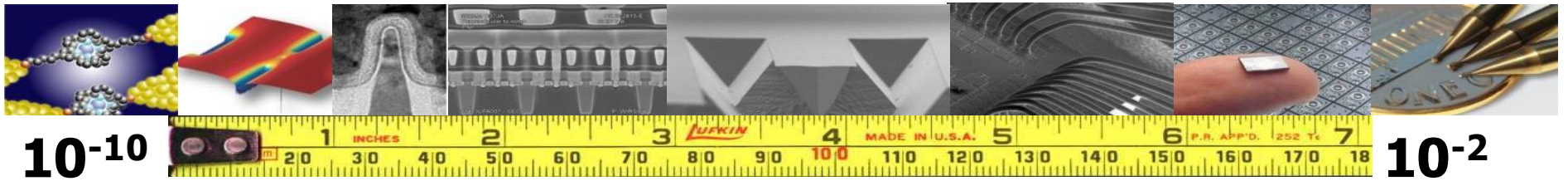
**System Integration**

**Design for X**

**Functionality;**
**Reliability;**
**Testability;**
**Yield;**
**Manufacturability;**
**Circularity;**
**Security;**
**Thermal;**
**Cost**

**Societal Needs**

- Communication
- Mobility
- Energy
- Healthcare
- E-society
- Defense
- …




$10^{-10}$ $10^{-2}$

# EU’s ChipAct ambition cannot succeed, without a joint EU vision, strategy and implementation of advanced packaging

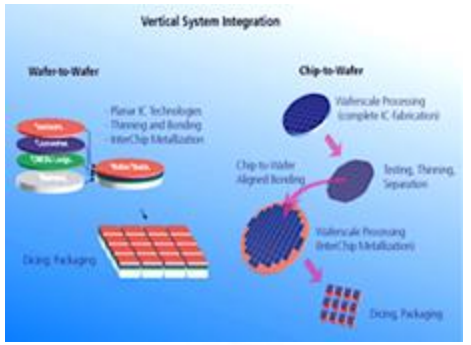
PACK4EU

Chips JU
Funded by the European Union
The project is supported by the CHIPS-JU and its members

# Three Level Packaging & Heterogenous System integrations

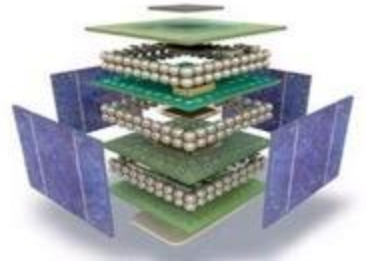
**Wafer level**

W2W; C2W, Chiplet
Wafer/panel fan-out
Thin wafer
TxI (Interconnect) &3D
Various functional devices
Integration of 3D printing



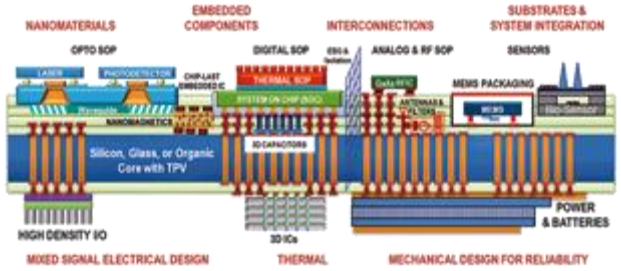

**Packaging level**

Various materials/ devices
3D & SiP
Novel interconnects
Device/package co-design
Hybrid technologies
Advanced thermal solutions



**Substrate/panel level**

Diverse substrates
Embedding
Self assembly
Panel
2D and 3D printing

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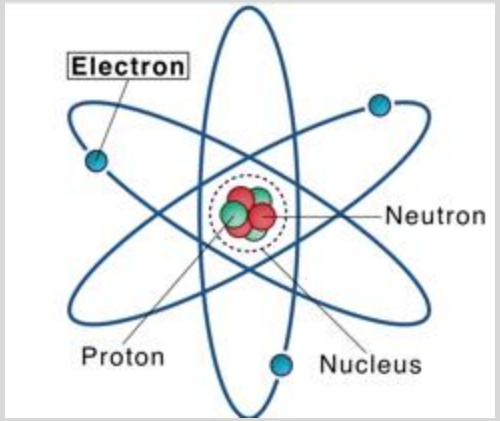
# Electron, Photon and Quantum

## Electron

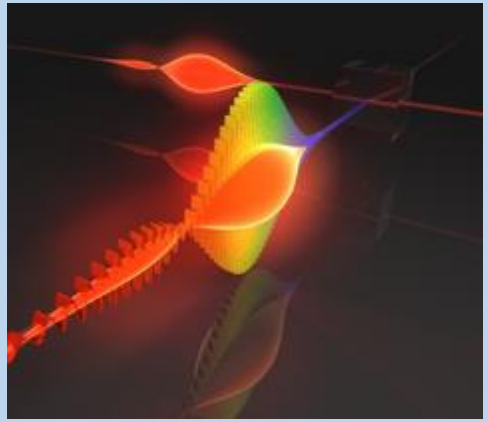
- Subatomic particle
- Negative electric charge

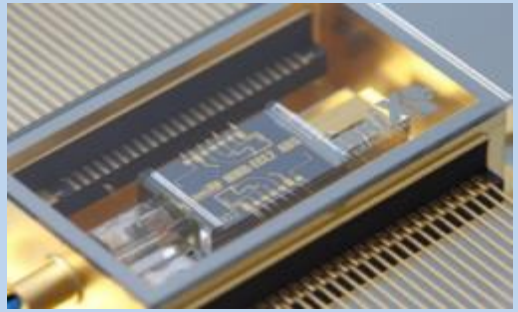



Electronics integration

## Photon

- Massless particle
- Electromagnetic energy carrier

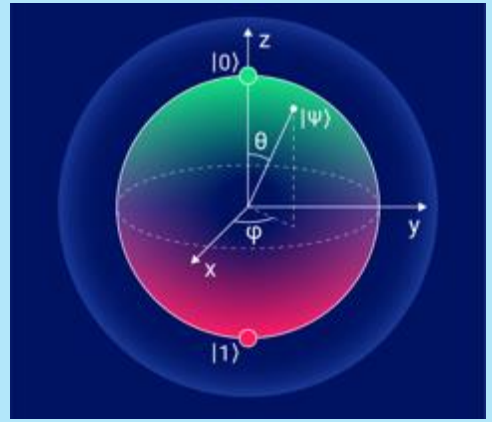


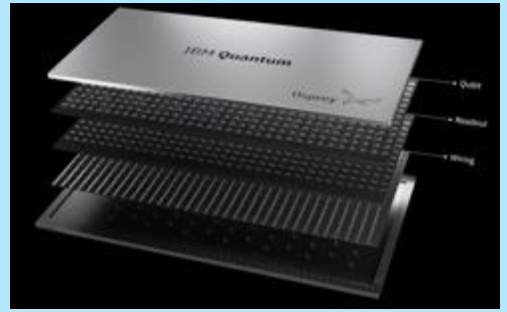


Photonics integration

## Quantum

- Discrete quantity of energy
- Entanglement, superposition



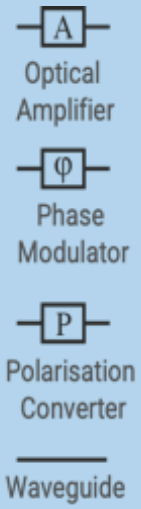
Quantum integration

# Main Components of Electronic, Photonic and Quantum Devices

## Electronic components

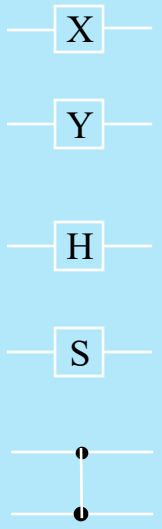

- Transistor
- Diode
- Resistor
- Capacitor
- Inductor
- connection

## Photonic components



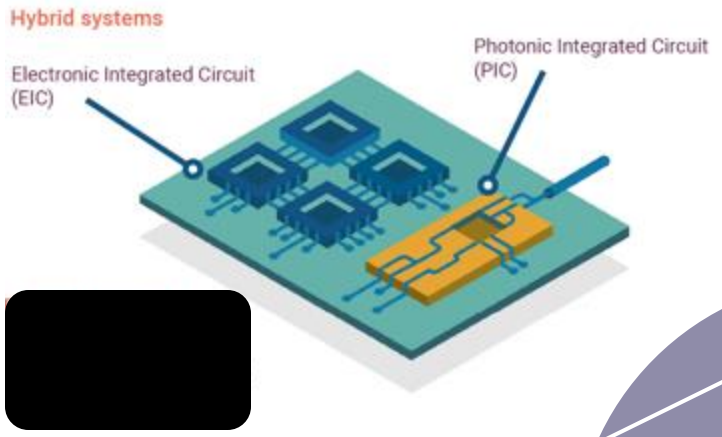

- Light source
- Resonator
- Modulator
- Detector
- Optical amplifier
- Waveguide
- Splitter/combiner

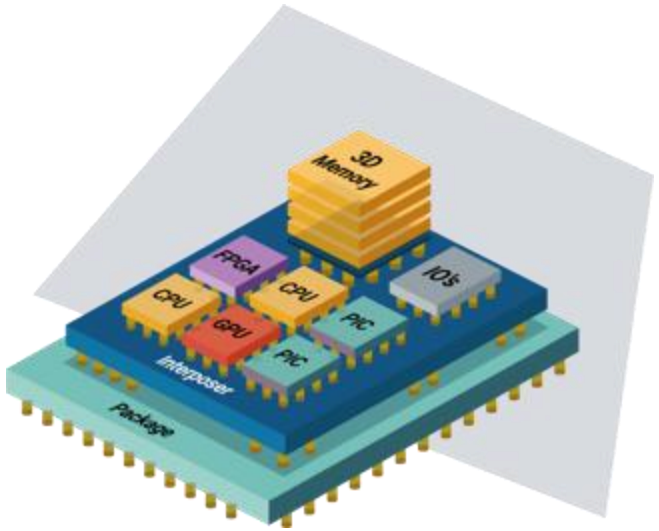
## Quantum components

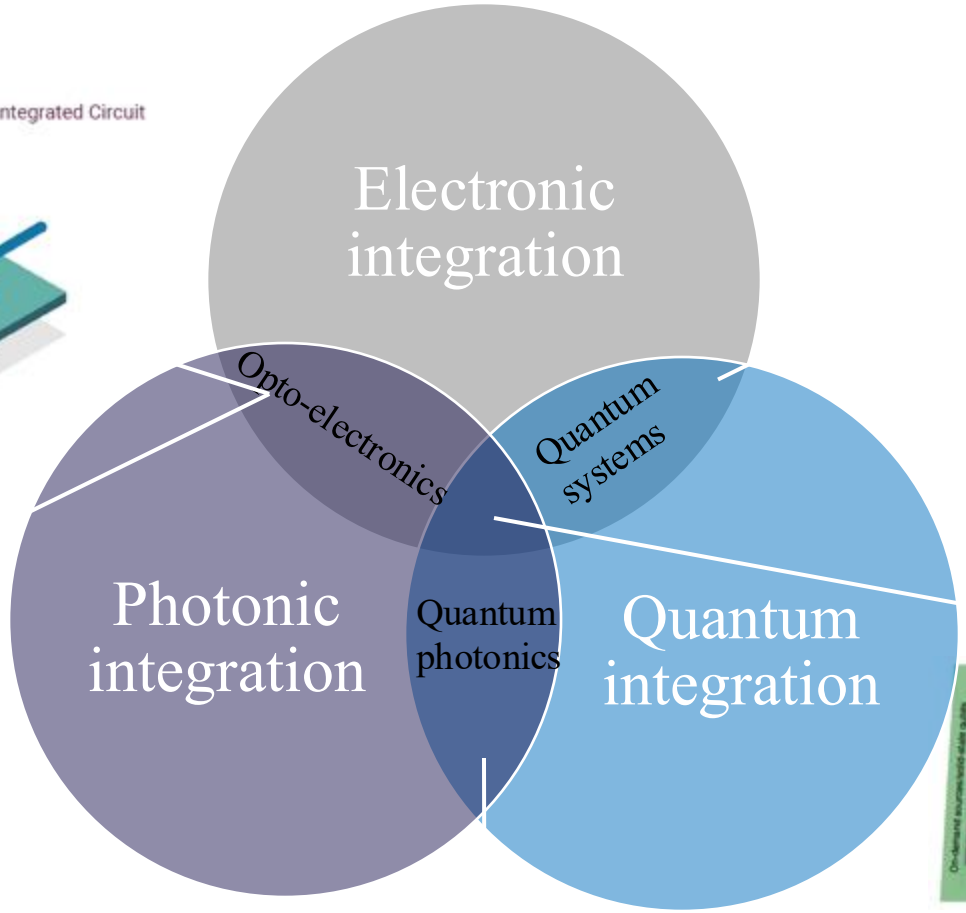


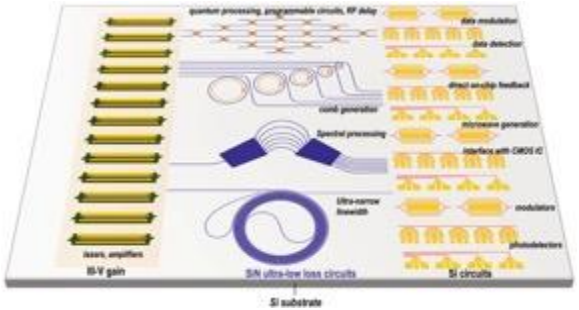

- Qubits
- Quantum gates
- Quantum memory
- Quantum measurement
- Quantum interconnect
- Error correction
- Electronic control

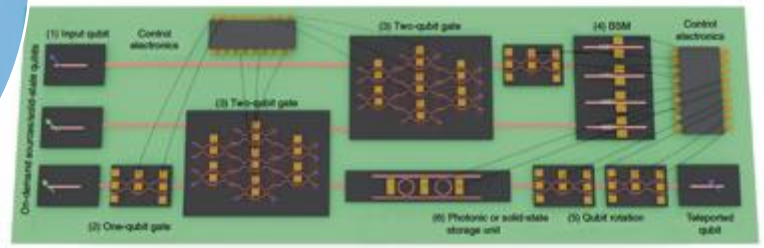
# Electronics, Photonics and Quantum Integration and Interaction



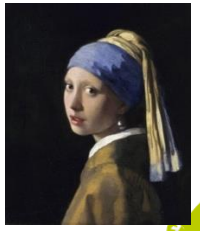





Electronic, photonic and quantum Integration system

# Universities in the Netherlands: Delft University

- Located in Delft, the home of the famous Dutch painter Johannes Vermeer and Antonie van Leeuwenhoek, the father of microbiology




Antonie van Leeuwenhoek
'Father of microbiology'

# Micro Electronics

**Bioelectronics**
Circuits and systems for monitoring, diagnosis and treatment of cortical, neural, cardiac and muscular disorders

**Electronic Components Technology and Materials**
Innovative devices, device integration concepts and novel microstructures and materials

**Circuits and Systems**
Theory and applications of circuits and systems, signal processing and VLSI circuit and system design methodology

**Electronic Instrumentation**
Electronic instrumentation, VLSI sensors and sensor electronics

**Electronic Research Laboratory**
Electronic circuit design

**Microwave Sensing, Signals and Systems**
Wireless systems for remote sensing and navigation, including microwave systems and radar applications


**Terahertz Sensing**
THz UWB front-ends and advanced antenna architectures for THz sensing instruments

# ECTM TEAM

**Willem v. Driel**

Pacakging Reliability, modelling

**GuoQi Zhang**

Packaging, reliability, WBS sensors

**Lina Sarro**

MEMS, sensors, actuators

**Daniel Pijnappels**

Cardiovascular detector-effector technology

**Massimo Mastrangeli**

Organs-on-chip, (self-)assembly

**Sten Vollebregt**

2D, WBG & emerging materials

**Clementine Boutry**

Biodegradable materials & technologies

**Qinwen Fan**

Power management, sensing amplifiers

**Henk v. Zeijl**

Research Fellow

**Filip Simjanoski**

Technician

**Adjunct research staff**

Michiel van Soestbergen

René Poelma

Jiajie Fan

***2025***

10 Post-doc researchers

60+ PhD researchers

25+ MSc students

15+ Nationalities

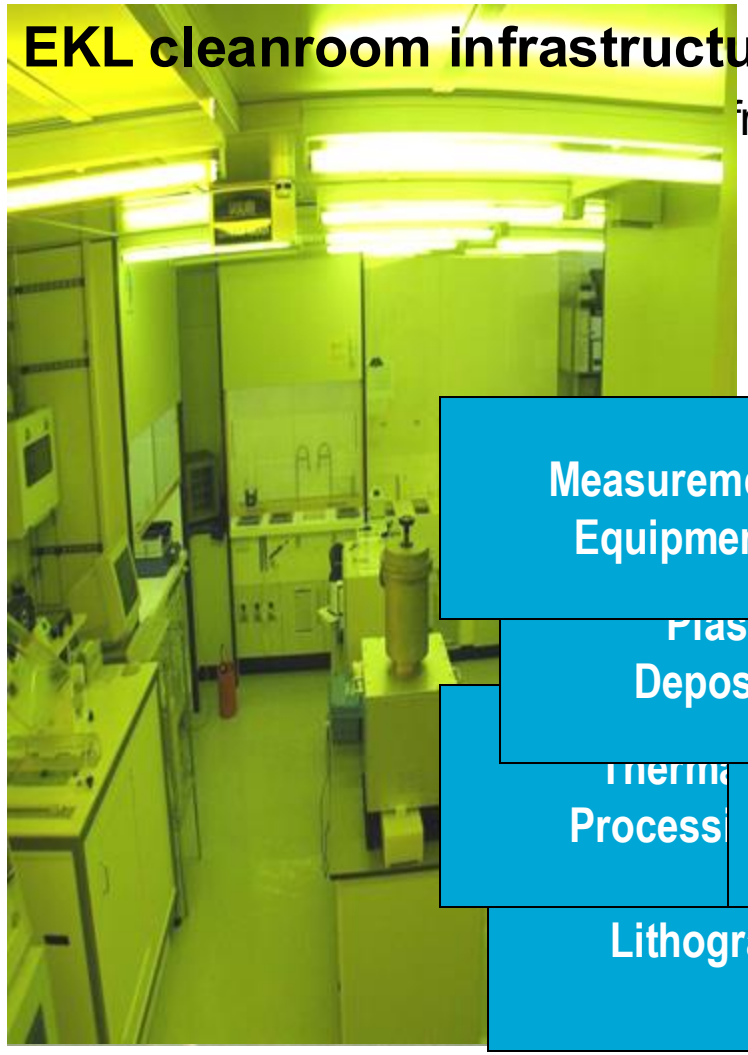
## Major collaborations

NXP, BOSCH, imec, DMT, TNO, ABB, ASML, CITC, HUAWEI, boschman technologies, Signify, mek marantz electronics ltd, amn, APC Advanced Packaging Center, AMPLEON, PRODRIVE TECHNOLOGIES, nexperia, Infineon, NWO, TU/e, Fraunhofer, ITEA, RVO, ECSEL JU

www.ectm.tudelft.nl

# EKL cleanroom infrastructure

rastructure for micro system integration



Measurem
Equipmer

Thin Film
Polymer la

Bonding &
Packaging

Plasma
Depositi

Evaporat

Physical Vapour
Deposition

Therma
Processi

Plasma Etc

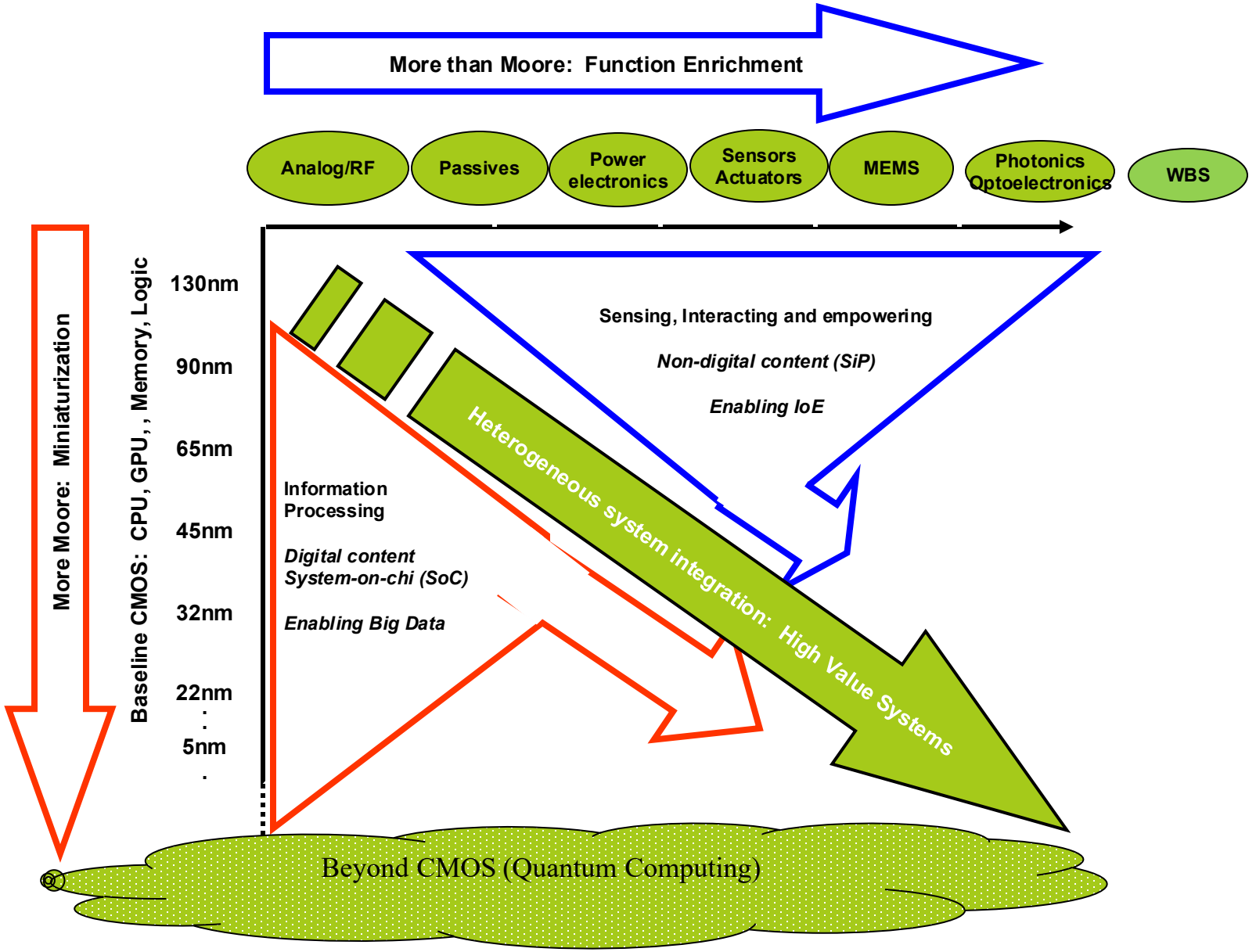
Epitaxy

Lithograp

Cleaning L

Wet Etchi

Else Kooi Laboratory


More than Moore: Function Enrichment
Analog/RF
Passives
Power electronics
Sensors Actuators
MEMS
Photonics Optoelectronics
WBS
More Moore: Miniaturization
Baseline CMOS: CPU, GPU, , Memory, Logic
130nm
90nm
65nm
45nm
32nm
22nm
5nm
Sensing, Interacting and empowering
Non-digital content (SiP)
Enabling IoE
Heterogeneous system integration: High Value Systems
Information Processing
Digital content
System-on-chi (SoC)
Enabling Big Data
Beyond CMOS (Quantum Computing)



TU Delft

# Competencies

## Interconnect

1. Nano Particle Metal based interconnects for wafer level packaging and SiP
2. Cost effective 3D TxV technologies for wafel level packaging
3. NanoCu and sintering process for power module
4. Interconnecting technology for Quantum computing at cryogenic condition
5. Interconnect for x (mechanical, electric, thermal, optic, microfluidic, etc.)
6. Hybrid bonding

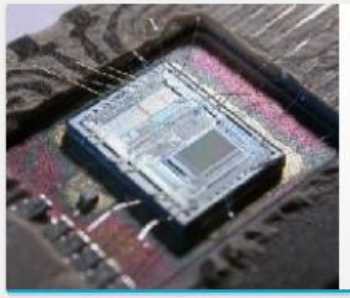
## Packaging

1. Co-designing of IC and packaging
2. Materials and process for MicroLED packaging & assembly (PD+PhD)
3. Sensor and multi-sensor system packaging, under harsh environments (PhD+PD)
4. Materials and processes for WBS packaging (5G, power, etc.) (PhD)
5. Biomedical packaging (Optogenetic and optoelectronic system integration for heart treatment) (PhD)
6. Photonic packaging (PhD)
7. Quantum packaging (PD)
8. Advanced thermal solutions (PhD)
9. Neromorphic chip packaging for edge AI

## DT/D4R

1. Multi-physics and multi-scale (1st principle, MD and FEM) simulation, optimization and characterization
2. Characterization, modeling and prediction of catastrophic failures (cracks, delamination, breaks, etc.) of materials and packaging
3. Characterization, modeling and prediction of time dependent failures (aging, degradation, fatigue, electromigration, creep, etc.) of materials, interfaces and packaging
4. Accelerated life time qualification and prediction of packaging and systems, using DT and AI
5. Prediction of system reliability with multi-failure modes
6. Characterization, simulation and design of thermal solutions for packaging and systems

# Education by ECTM

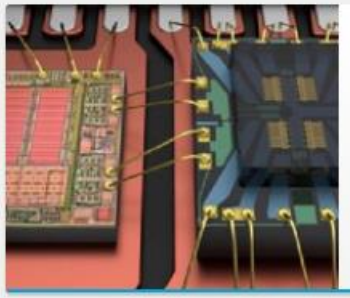


## ET4391 Advanced microelectronics packaging

Basics and state-of-the-art of semiconductor device packaging and system integration.

## ET4icp IC technology lab

Hands-on experience on process simulations, fabrication in the EKL cleanroom and measurement on the fabricated devices



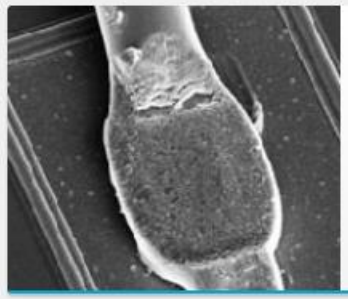
## EE3365TU Basics of Microfabrication

*(not running)*

## ET4289 Integrated circuits and MEMS technology

introduction in the fabrication technologies used for Integrated Circuits and MEMS

## EE4C10 Analog circuit design fundamentals



## ET4277 Microelectronics reliability

Reliability issues involved in electronic components and system

# Power Electronics (PE) Group, University of Twente (UT)

## PI's

Assoc. Prof. Ray Hueting

Prof. Gert Rietveld

Prof. Thiago Soeiro

## Core competences

- Power electronics/device test/module design & realization
- Electrical characterization & degradation in harsh environments (e.g., high T, stress)
- Multi-physics (FEM)/compact modelling for system integration (e.g., electro-thermal, thermo-mechanical)

## Major education & research infrastructure

- Dedicated equipment for power electronics
- (e.g., AC & DC voltage sources, oscilloscopes)
- Semiconductor and battery test equipment (e.g., thermal chamber, general testers)
- On-wafer: probe stations, DC/RF-CV & optical equipment
- WBG device realization: cleanroom (MESA+ nanolab)

## Contact


**Department/Group**
Electrical Engineering
Power electronics (PE) group

**Relation to Institutes**

MESA+ institute

**PI's Emails:**
**R. Hueting:** r.j.e.hueting@utwente.nl
**G. Rietveld:** g.rietveld@utwente.nl
**T. Soeiro:** t.batistasoeiro@utwente.nl

**Linkedin:**
https://www.linkedin.com/company/105246447/admin/dashboard/

**Website:**
https://www.utwente.nl/en/eemcs/pe/


## About the Power Electronics Group

1) **6 Academic Staff** (2 full prof.; 3 assoc. prof., and 1 assistant prof.).

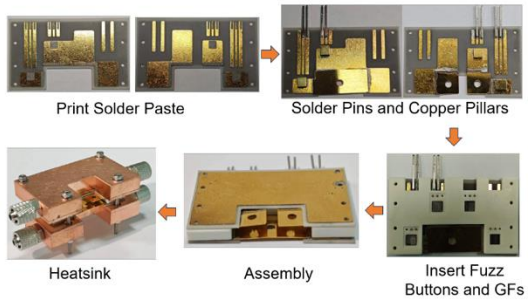
2) **27 PhDs/Postdocs** (8 Power Electronics for E-transportation; 7 Electronic Devices & Packaging; 4 Measurement Tech.; 4 Smart Grids; 4 Battery Electronics), and approx. 15 MSc thesis works (annually).

3) **Related courses and levels:**

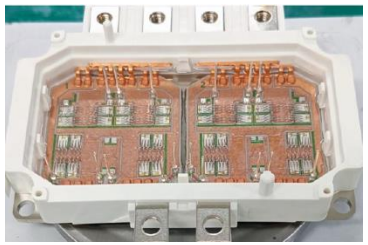
Semiconductor devices (BSc 2nd year EE & AT)
Advanced semiconductor devices (MSc)
Power electronics converters (MSc)
Advanced Power electronics (MSc)

4) **Semiconductor Packaging R&D:**

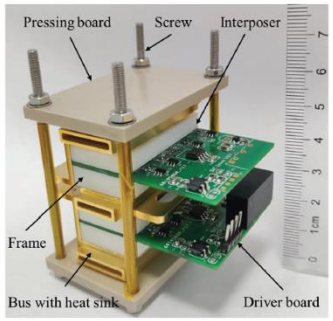
**SiC half-bridge module with cooling**



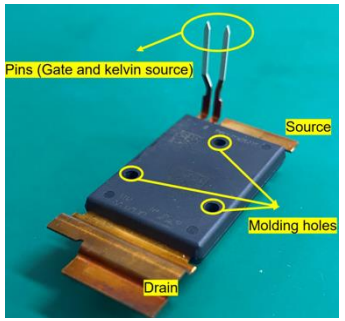

**900A SiC half-bridge module**



**Pressure Contact Technology for Multi-chip SiC Modules and Low Parasitics**




**SiC power module assembly based on silver sintering bonding**



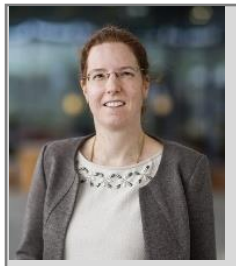
# TU/e – Mechanical Engineering Department

Olaf van der Sluis
Materials and Interfaces in High-Tech Systems, Mechanics of Materials

- **Core Competencies**
  thermo-mechanics, (packaging) residual stress, damage and fracture mechanics, adhesion, delamination, reliability, thin film mechanics, multiscale mechanics, materials processing, design optimization, manufacturing, computational modelling and simulation, reduced order modelling, digital twins
- Major research and education infrastructure
  Multi-scale lab, supercomputing lab
- Numbers of PhD and MSc: 10 / 25
- Names of related courses and levels
  - Fracture Mechanics (MSc - core course)
  - Mechanics and Adhesion of Thin Films (PhD)
  - Solid Mechanics (BSc)
  - Digital Twins of Devices and Systems (BSc)

Lambèrt van Breemen
Polymer Mechanics, Processing and Performance

- **Core Competencies**
  contact/surface mechanics, friction and wear, thin film mechanics, thermo-mechanics, small-length scale mechanical testing, micro-structure quantification, polymer processing, additive manufacturing, computational modeling and simulation
- Major research and education infrastructure
  Mechanical testing lab, rheology lab, structured fluids lab, multi-scale lab, supercomputing lab
- Numbers of PhD and MSc: 21 / 8
- Names of related courses and levels
  - Multiscale modelling for polymer mechanics (MSc)
  - Advanced and Additive Manufacturing (MSc)
  - Strength and structure (BSc)
  - Experimental and numerical skills (BSc)
  - Mechanics (BSc)
  - RPK (PhD/postacademic)
  - Coating Technology (PhD/postacademic)



Ruth Cardinaels
Multiphase materials, Processing and Performance

- **Core Competencies**
  Rheology, materials structure-property correlations, rheo-optical and rheo-dielectrical techniques
- Major research and education infrastructure
  Rheology lab
- Numbers of PhD and MSc
- Names of related courses and levels
  - Rheology (MSc)