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Exciting and new; based on existing and proven

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Philips Micro Devices
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innovation + you

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  - Optical
  - Acoustic
  - µ-fluidic
- Conclusions

MEMS & Micro Devices - in Innovation Engineering

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Diagnosis & Treatment

Precision Diagnosis

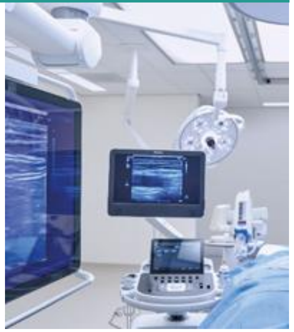
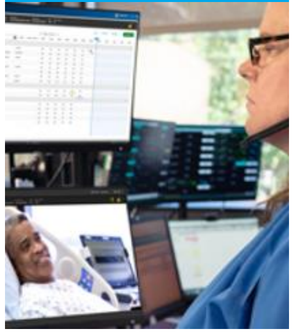


Image-Guided Therapy

Connected Care



Connected Care

Personal Health

Personal Health

Operations, delivery & services

Innovation & strategy

Innovation Engineering

MEMS & Micro Devices

Philips

ThermoFisher Scientific, TNO, MyCartis, intralox, Johnson & Johnson Vision, Abiomed, imec, Océ A Canon Company, Signify, Bosch, ASML, Thales, Heraeus, Lynred, VDL, gsk, NXP

External medical & high-tech companies

Supporting internal and external customers

MEMS & Micro Devices

Process Development and Manufacturing

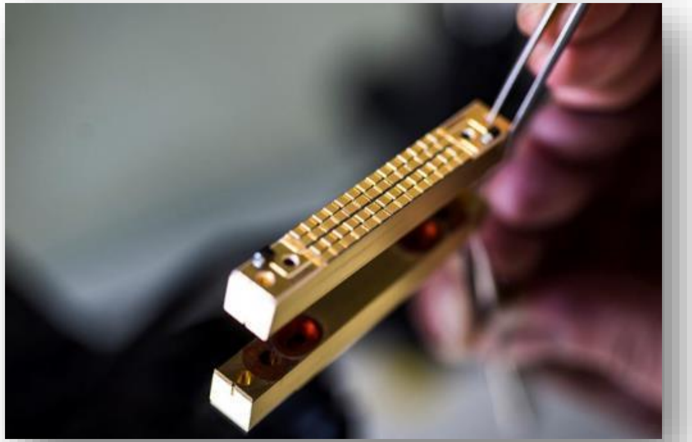
Certified for
ISO 13485
ISO 9001
ISO 14001

MEMS & thin film products

2650 m²
Cleanroom
FTE: ~100

High Tech Campus, Eindhoven

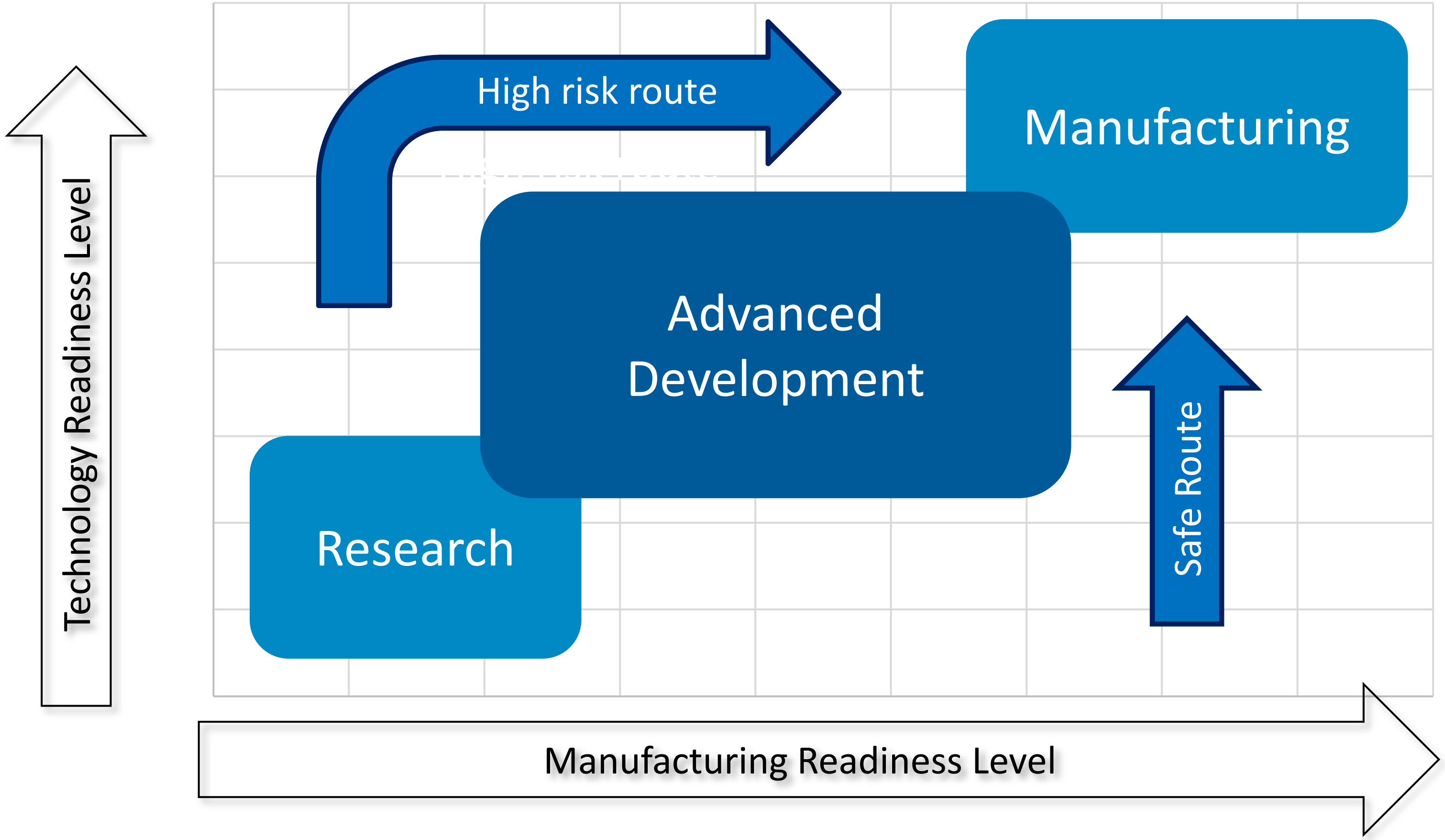
Micro (Device) assembly & complex PCBA



2500 m²
Factory +
Cleanroom
FTE: ~70

"Greenhouse" Strijp-S, Eindhoven

Development philosophy



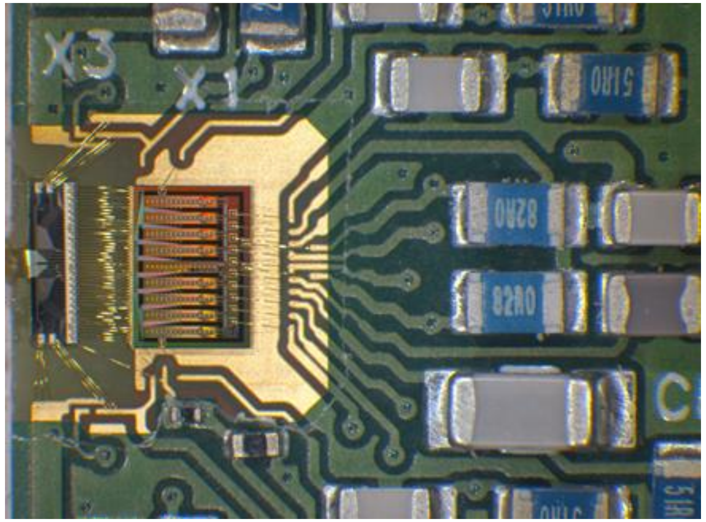
Advanced development

- Focus on de-risking / quick learning
- Select concept & technologies
- All functions to be incorporated into the Architecture are proven
- **Process windows and Transfer functions** for CTQ's known

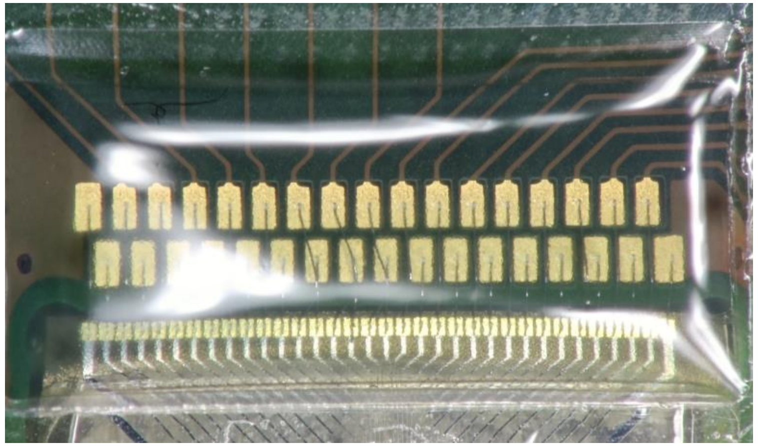
Doing the exciting and new based on the existing and proven

Existing and proven semiconductor assembly processes

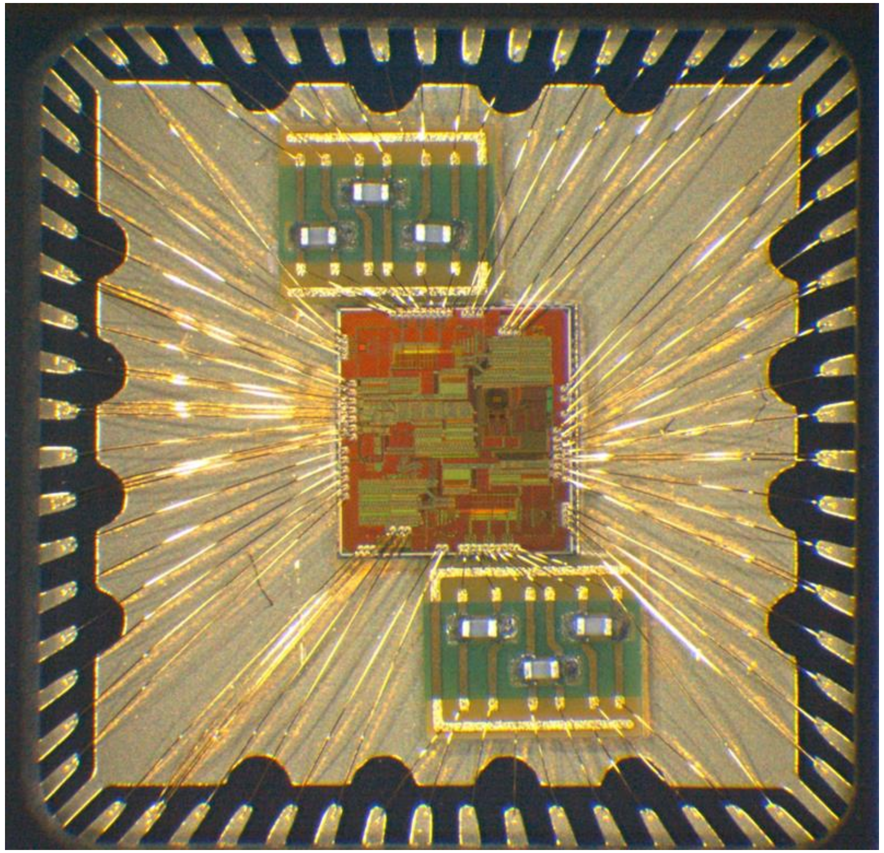
Conventional technologies
- Die bonding with adhesive or solder
- Flipchip soldering
- Au and Al wirebonding
- ACF bonding of die to carrier (flex)
- Encapsulation: moulding or globtop
- PCB assembly



CMUT benchboard

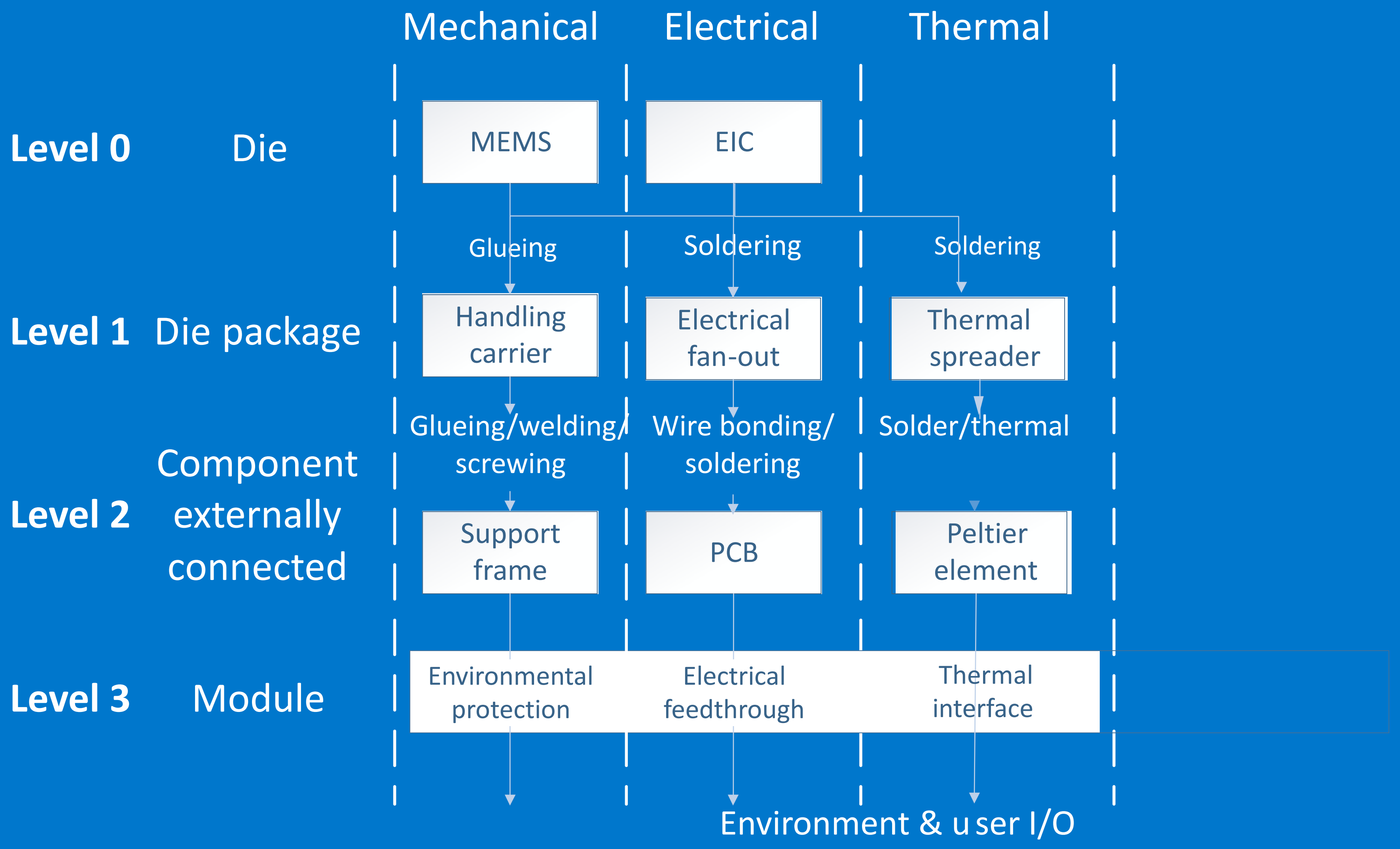


Encapsulated Au wires

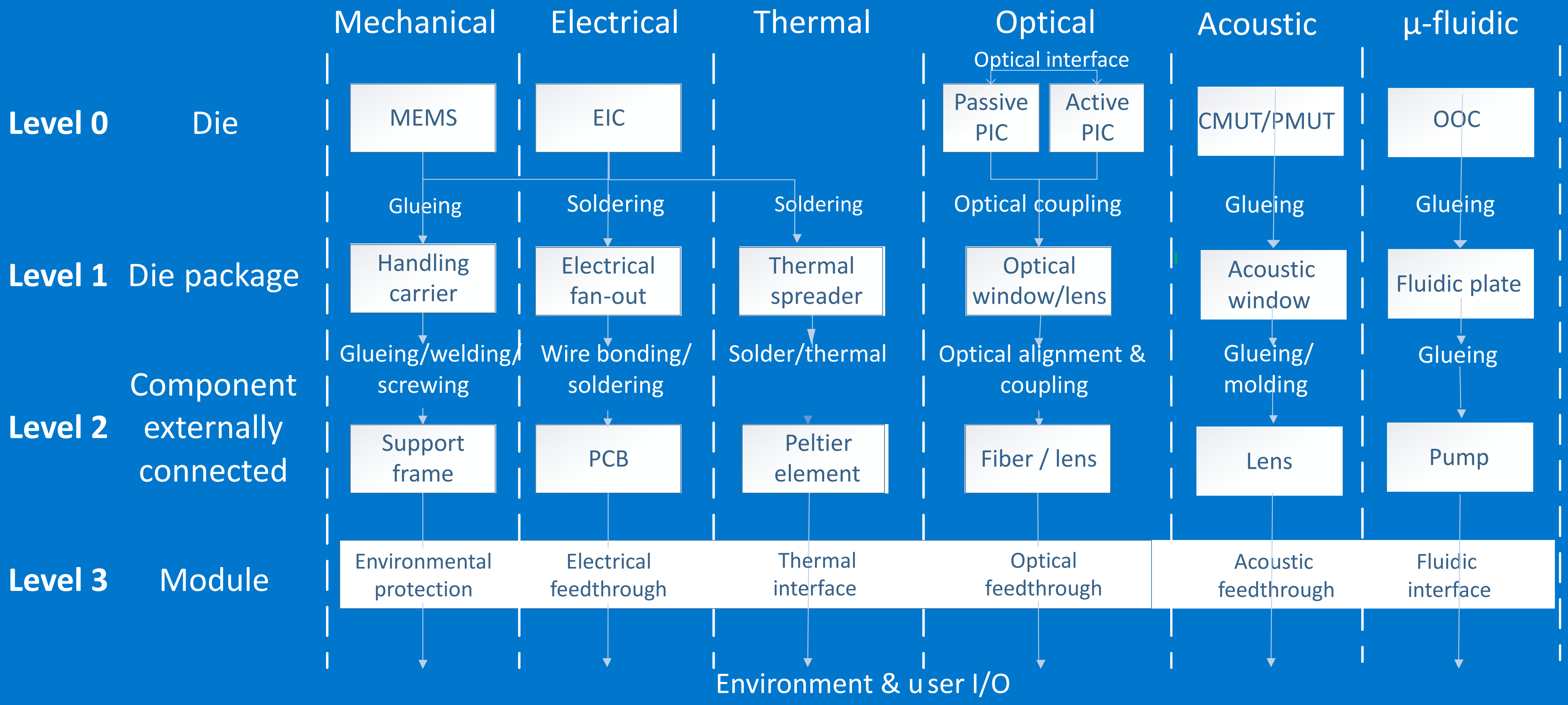


ASIC with added capacitors

Known and proven interfaces semiconductor



New extended interfaces



Interface challenges for new application area's

Interface	Challenges
Thermal/Mechanical/electrical	Miniaturisation, 2D->3D, new interfaces
Acoustic	Material stack, interface and shape
Optical	Relative position accuracy and stability
µ-fluidic	Leaktight, environmental conditions

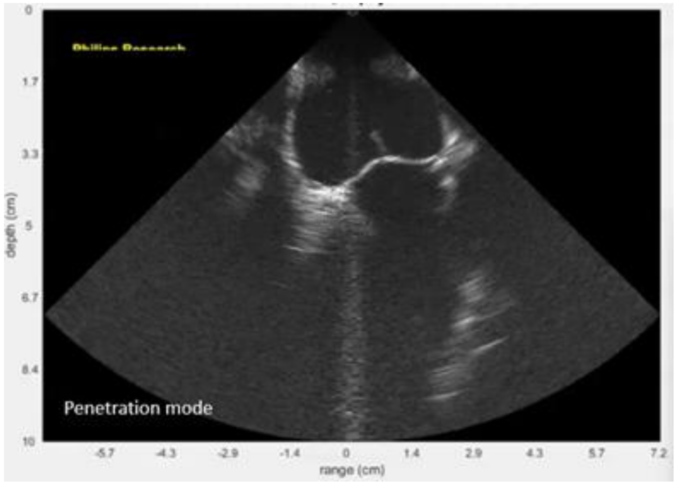
Miniaturisation conventional technology

Imaging core ICE

- Acoustic ultrasound sensor
  - Single crystal technology
  - Side looking
  - 2D and 3D images
  - ∅ 3 mm (9 Fr)

- Assembly challenges
  - Connecting cable assy to acoustic assy
  - Handling odd form factor (2.8 m cable)

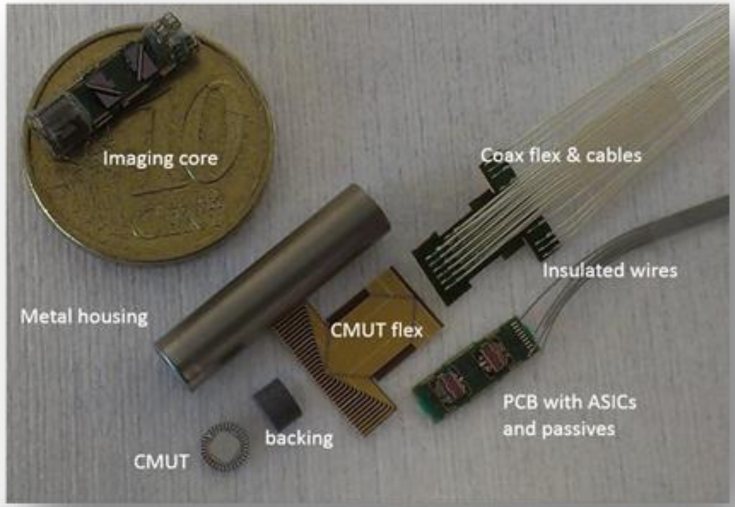
- Proven assembly technologies
  - Component placement
  - Au wirebonding
  - Globtop

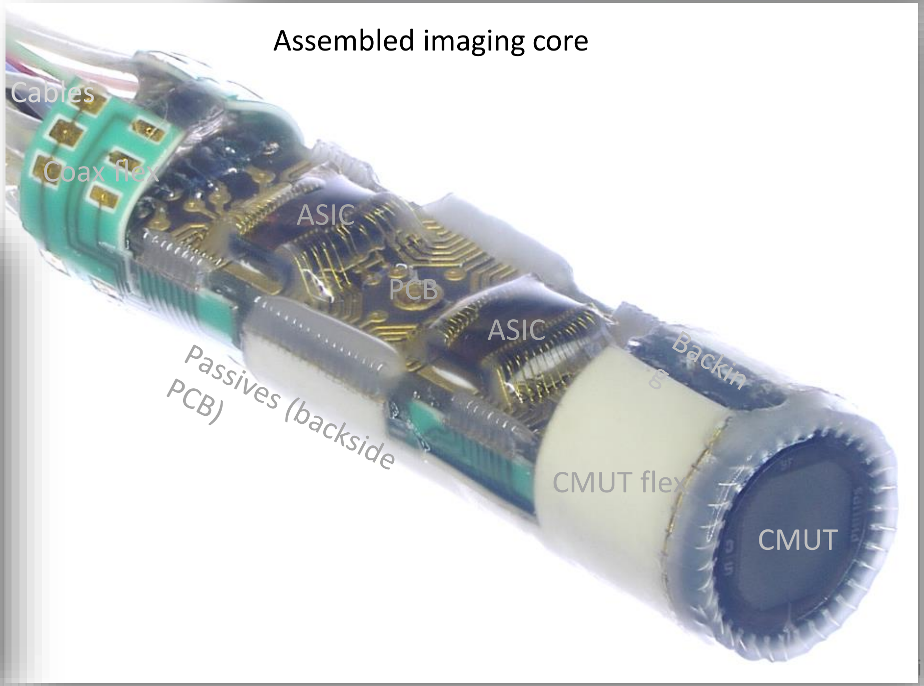


Miniaturisation conventional technology

Imaging core FL-ICE

- Acoustic ultrasound sensor
  - CMUT technology
  - Forward looking
  - 2D images
  - ∅ 4 mm (12 Fr)
- Assembly challenges
  - Miniaturisation
  - 3D form factor based on conventional LCP flex
  - Wirebonding on side edge of flex
- Proven assembly technologies
  - PCB assembly
  - Die bonding
  - Au wirebonding
    - ASIC/PCB
  - Al wirebonding
    - CMUT/flex

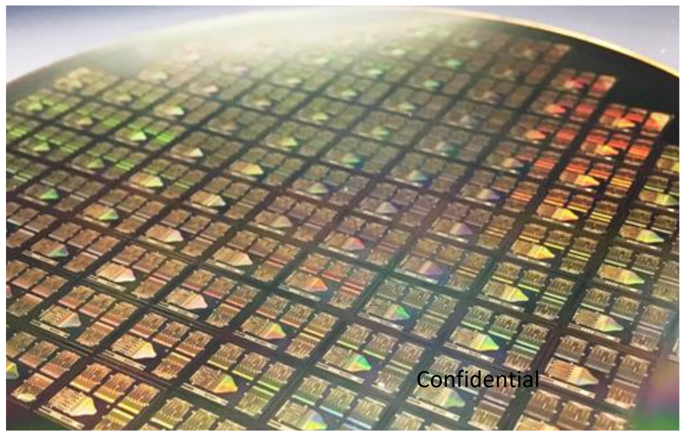


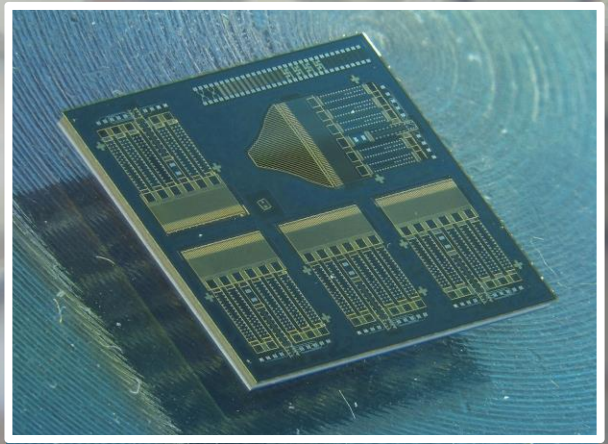


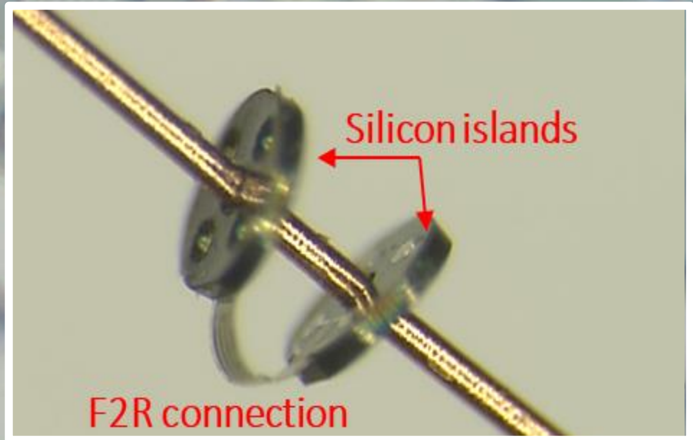
New 3D miniaturisation platform: F2R

Flex-to-Rigid (F2R) silicon carrier

- Wafer level processing with integrated interconnects
- Seamless sensor integration
- 2D assembly and folding into 3D configuration
- Compatible with proven technologies

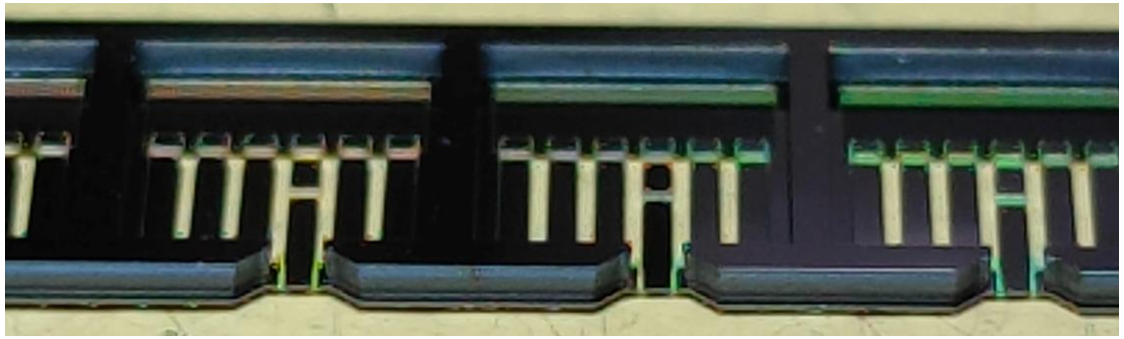


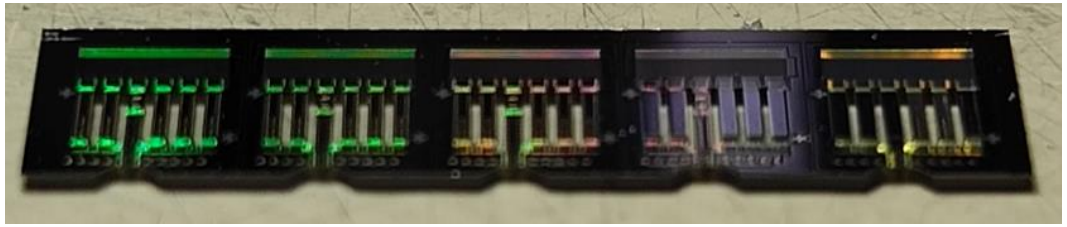




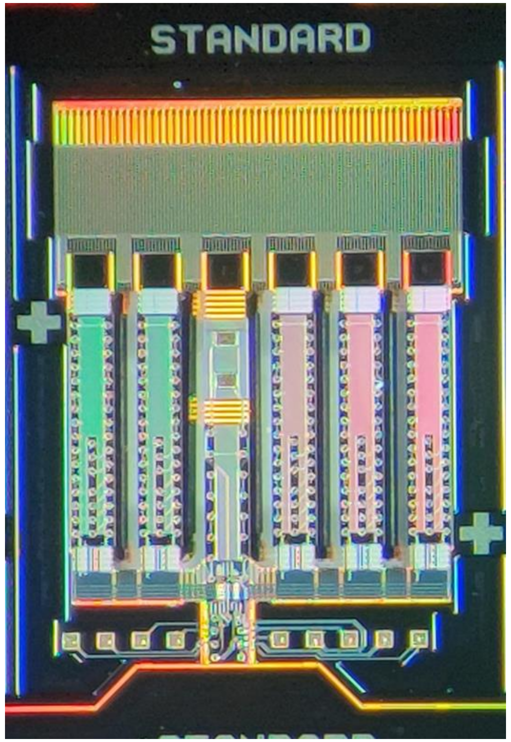
New 3D miniaturisation platform: F2R
Key characteristics

- Starting material SOI wafer
  - Device layer 40 µm, handle 380 µm
- Tracks embedded in two layers of PI bridging Si islands
  - Enables folding due to flexibility
- Wafer divided into frames for handling and processing





Frames used in processing



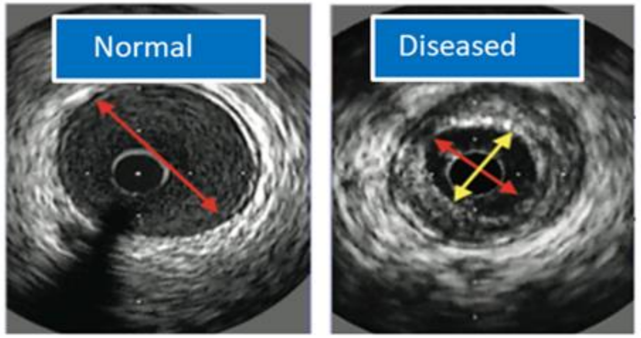
New 3D miniaturisation platform: F2R

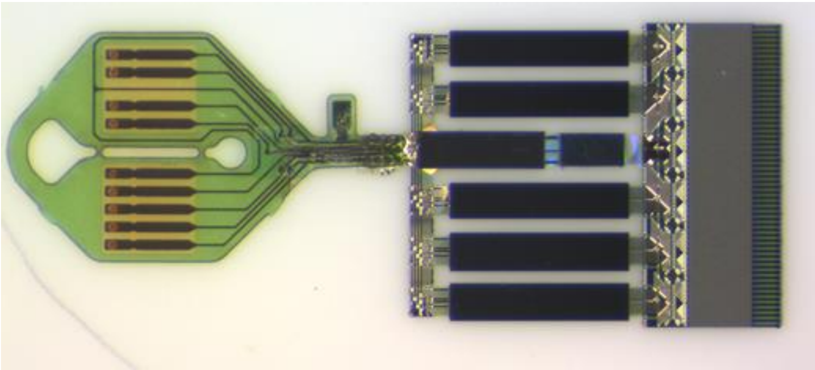
IVUS imaging core

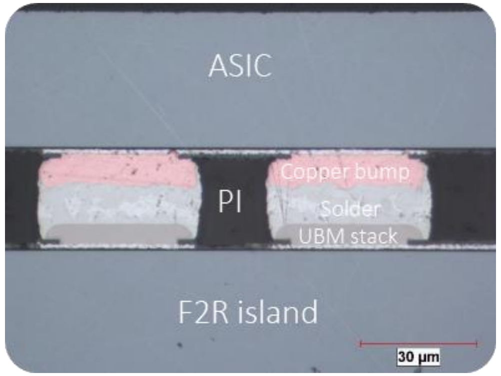
- Acoustic ultrasound sensor
  - CMUT technology: 114 element lines
  - 6 ASIC's and 1 capacitor
  - 360 degree image
  - 2D plane view
  - ∅ 1 mm (3 Fr)

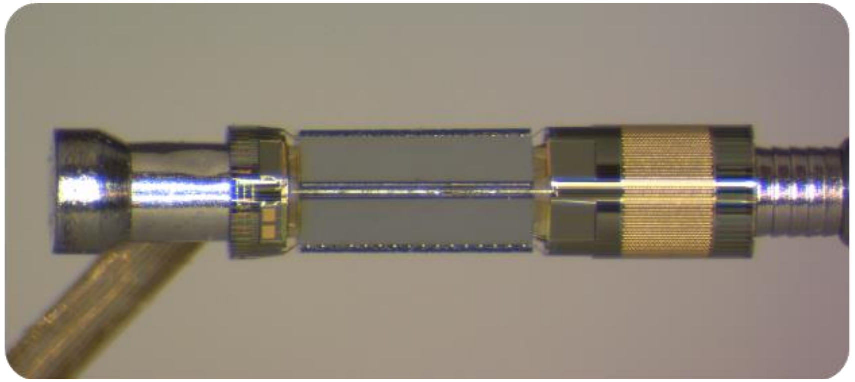
- Assembly challenges
  - Miniaturisation
  - Assembly processes on 40 µm thick Si islands
  - 3D form factor

- Proven assembly technologies
  - Flip chip die bonding
  - ACF flex attach
  - Underfill
- New assembly technologies
  - 3D shaping and fixation with adhesive









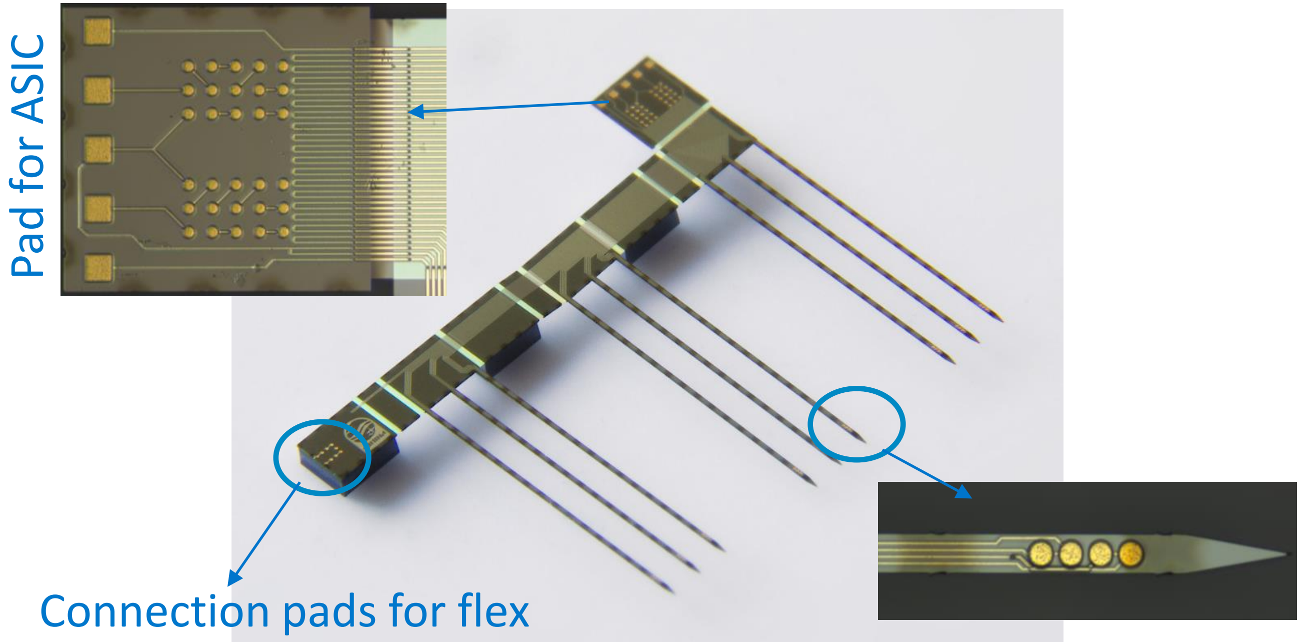
New 3D miniaturisation platform: F2R

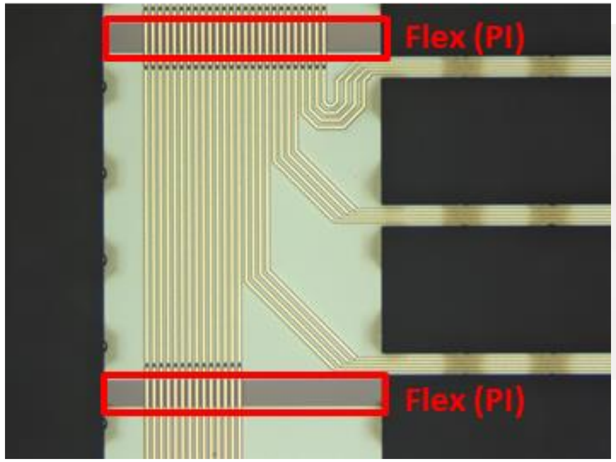
Bio-MEMS

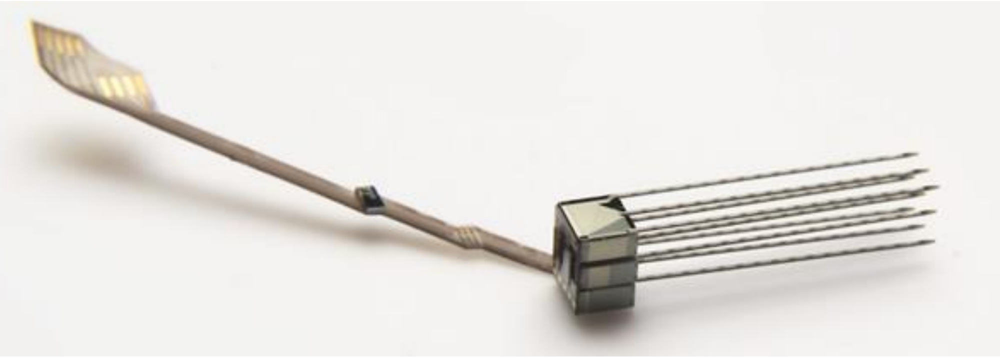
- µ -needle array
  - Sensing electrodes
  - Array of 5 mm long needles, 72µm wide * 40µm thick
  - Array can be formed by folding or rolling
  - Integration of ASIC’s for data processing
  - Flex to interface with external electronics

- Assembly challenges
  - 2D assembly and 3D geometry
  - Handling small delicate parts

- Proven assembly technologies
  - ASIC flipchip bonding
  - ACF flex bonding
- New assembly technologies
  - F2R folding and fixation with adhesive



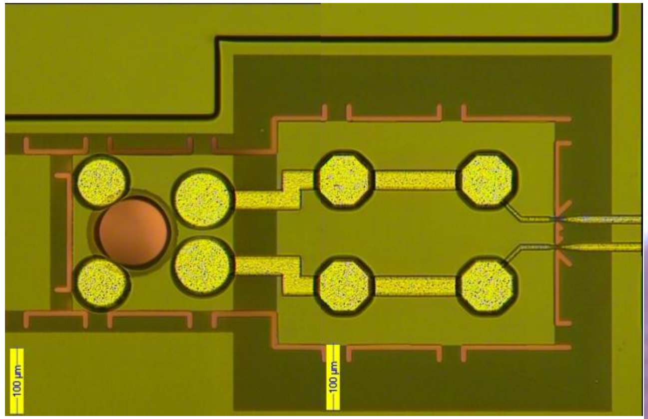


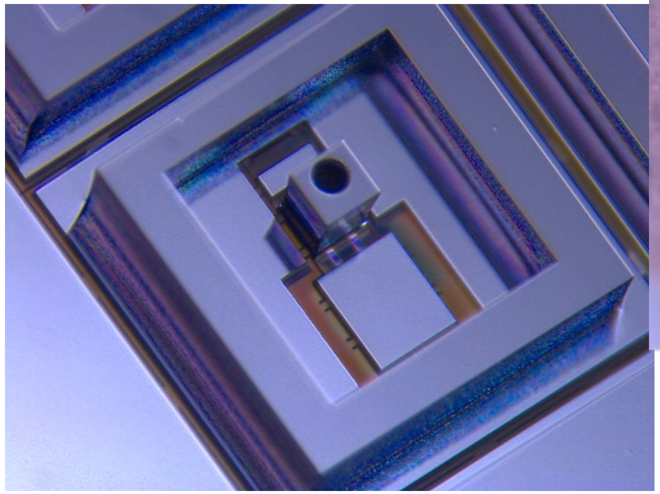


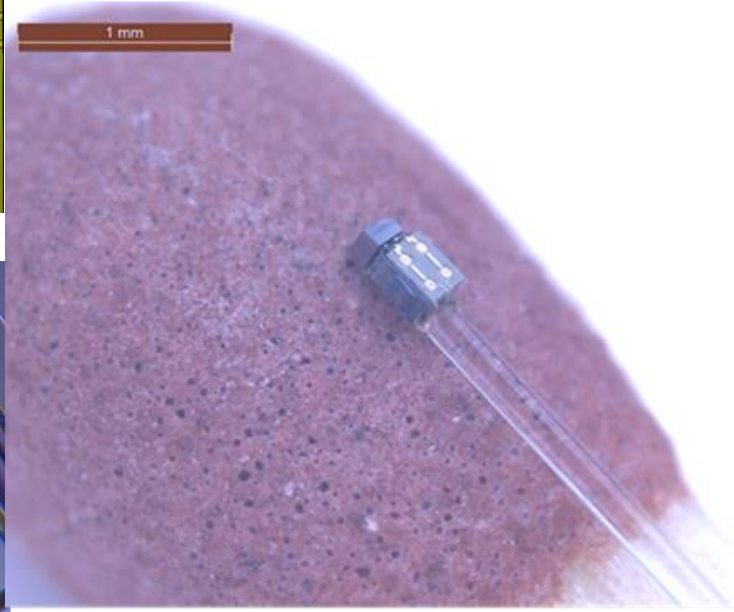
Folded µ-needle array

New 3D miniaturisation platform: F2R
Photonic

- Optical link module
  - Power transfer or data transfer
  - Dimensions enable integration in catheters
  - Footprint enables flipchip soldering to other carrier
- Assembly challenges
  - Miniaturisation and 3D geometry
- Proven assembly technologies
  - VCSEL flipchip bonding
  - Optical fiber insertion and fixation with adhesive
- New assembly technologies
  - F2R folding and fixation with adhesive

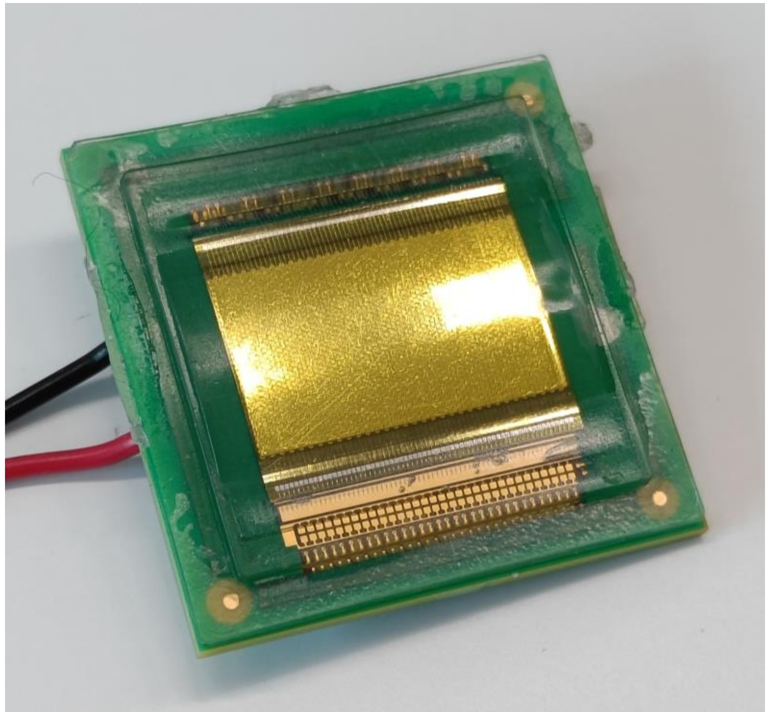






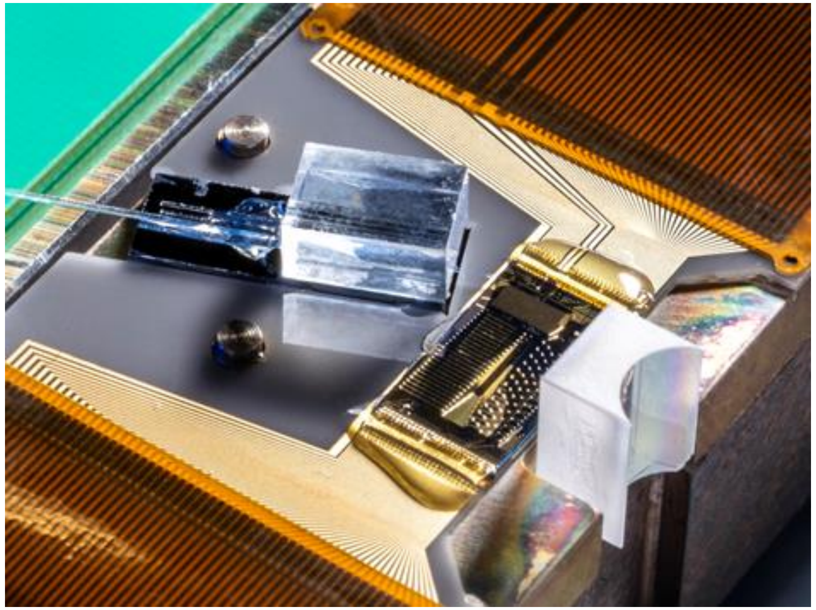
New interfaces: Acoustic

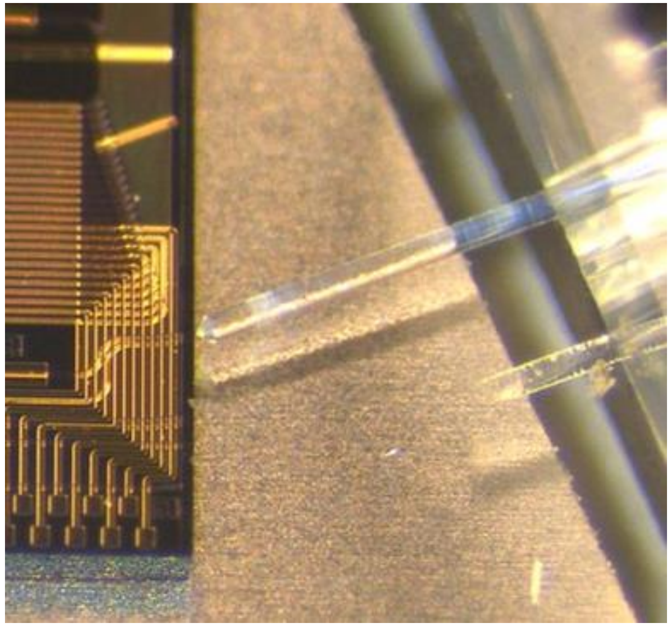
- Ultrasound imaging module
  - CMUT technology
- Assembly challenges
  - Acoustic matching different materials
  - Stress resistance to exposure to humidity/water/temperature
- Proven assembly technologies
  - Die bonding with adhesive
  - Al wirebonding
- New assembly technologies
  - Window application
  - Lens component placement with adhesive



New interfaces: Optical

- Lidar for landing assistance
  - Optical phase array for beamsteering
  - PIC with fiber input and lens output
- Assembly challenges
  - Submicron alignment lensed fiber (1.5*0.5micron waveguide)
  - Stable submicron fixation of fiber (<100nm)
  - Lens placement accuracy (odd shape)
- Assembly carrier and concept
  - Developed together with CITC and TNO
  - Cooling design by TNO
  - Electrical assembly by CITC
  - Optical assembly by Philips
- New assembly technologies
  - Active optical alignment fiber to PIC
  - Glue fixation with optimised curing profile
  - Lens component placement with adhesive

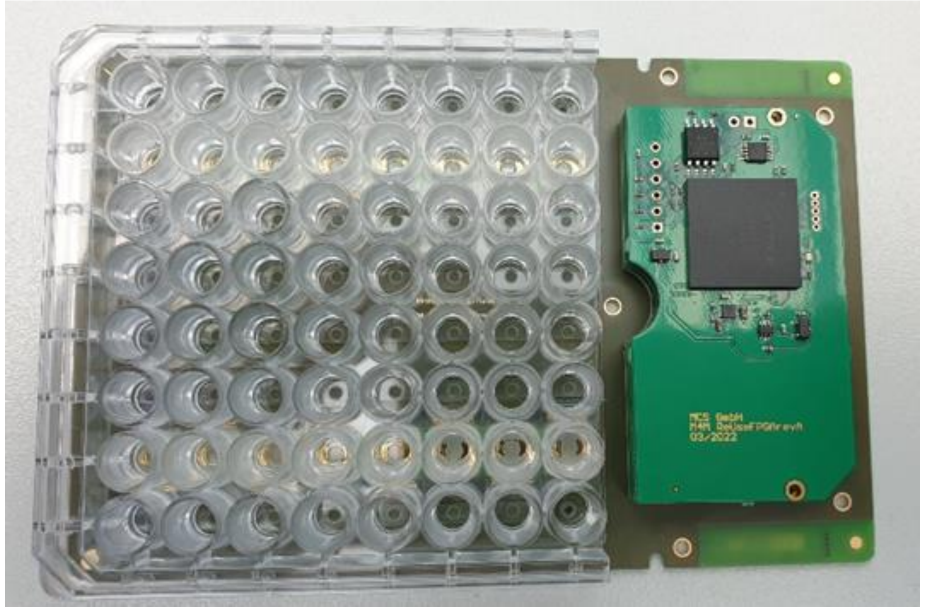




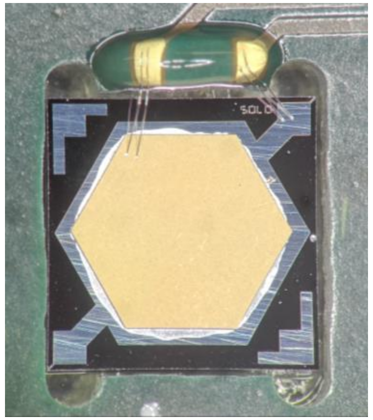
NEWCONTROL

This work has been funded by the European Commission and ECSEL Joint Undertaking through the Project NEWCONTROL (826653).

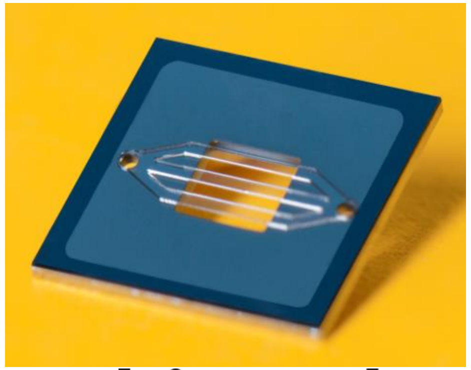
New interfaces: µ-fluidic



- Smart Multi-well plate platform
  - Organ on chip dies with electrodes
  - Silicon micro pumps to create a fluidic flow
  - Positions to buffer required fluids (fresh & waste)
  - Electronics to process data acquisition
- Assembly challenges
  - Leak tight assembly
  - Bio-compatible materials and low temperature processes
  - Environmental protection
    - Incubator conditions exposure 4 weeks (40 C / high humidity)
    - Water exposure
- Proven assembly technologies
  - Adhesive die-bonding
  - Wirebonding of dies and micro-pumps
  - Encapsulation of wirebonds (dispense process)
  - Sealing



Si micro pump
Fraunhofer EMFT



bi/ond.
Organ on Chip developed with conventional silicon-based microfabrication

Moore4Medical
ECSEL Joint Undertaking
H2020-ECSEL-2019-IA-876190
www.moore4medical.eu

Conclusions

- The new and exiting development fundamentals
  - Re-use as many as possible proven technologies and standard production equipment
  - Identify new interfaces and requirements
  - De-risk unknowns in a structured Advanced development approach
  - Release new technologies on standard production equipment

- New F2R platform enables next steps in miniaturisation and integration of new functionalities

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