DRD 7.6b – Common Access to 3D and Advanced Integration

DRD7.6

Common Access to 3D and Advanced Integration

Strategic Goal

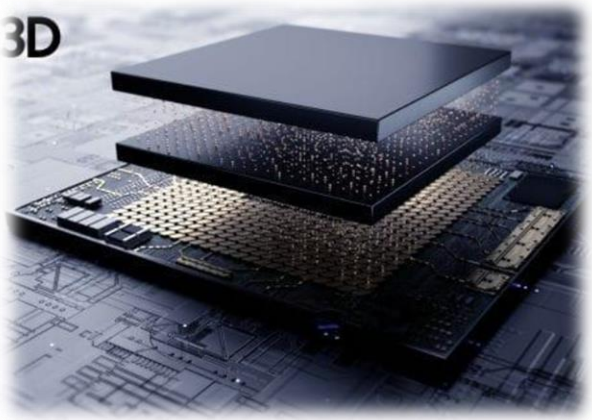
- Provide/facilitate the access to advanced chiplet and 3D integration technologies
- Integration of SiPh chip and optical fibers on detector module
  - Reduce development costs and production time by in-house facilities

Performance Targets

- Shared competences/experiences and infrastructures/processes
- Built-up and maintain capability for wafer stacking/multi-tier, chiplet and SiPh integration

Supported Technologies

- TSV-last and redistribution layer (RDL) technologies
- Chiplet, 3D/2.5D integration, W2W, C2W and C2C bonding w/wo solder
- Integration of monolithic/hybrid PIC on detector



⟹ ***DRD 7.1⇔DRD 7.6***

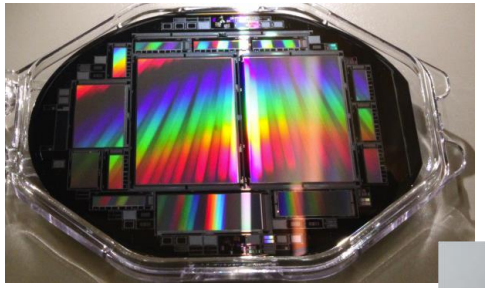
HLL – Semiconductor Laboratory of the Max Planck Society

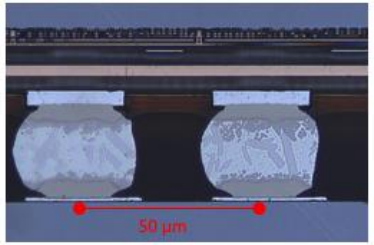
Courtesy: Laci Andricek and Jelena Ninkovic

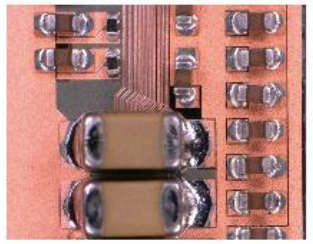
- Core competence
  - Experiment and physics driven **development, design, and fabrication** of silicon sensors and full camera systems
- Recent and current lighthouse projects
  - Belle II PXD, Athena WFI, TRISTAN, EDET 80k and many more
- Sensor portfolio
  - APS (DEPFET), pnCCD, SDD, Avalanche devices (LGAD), passive pixels, strips ..
- Facilities & technologies
  - Currently 1000 m^2 clean room, from 2024 on 1500 m^2 up to ISO3
  - Full process line for 150 mm wafers, to be extended to 200 mm
  - Post-processing and interconnection line (RDL, UBM, flip-chip..)
  - Extension towards 3D/2.5D integration and wafer level packaging

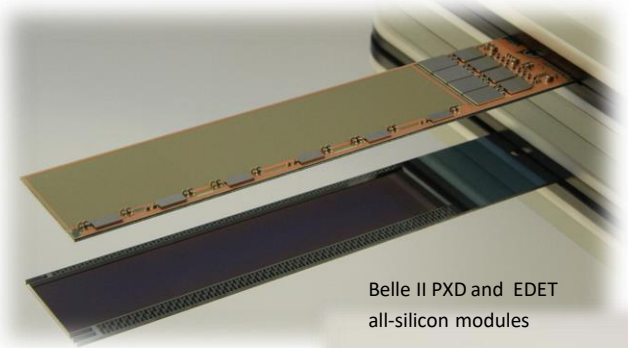
From end 2023 @ Research Campus Garching

pnCDD on 150 mm wafer

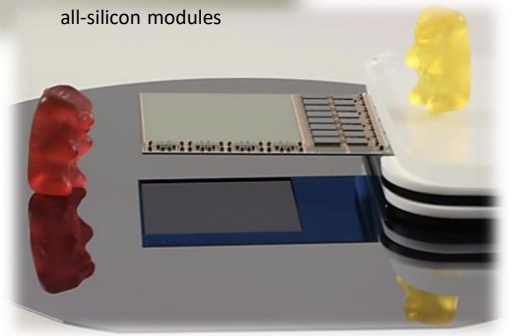




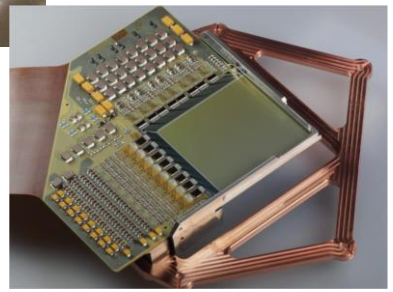


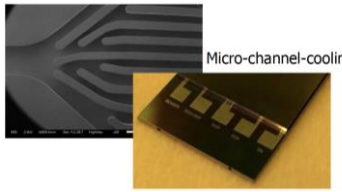


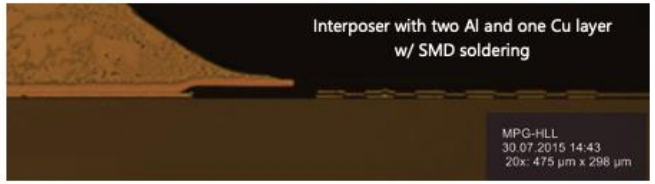
Belle II PXD and EDET all-silicon modules



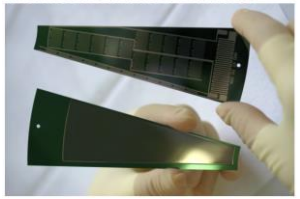
Athena DEPFET module







Thermo-mechanical modules

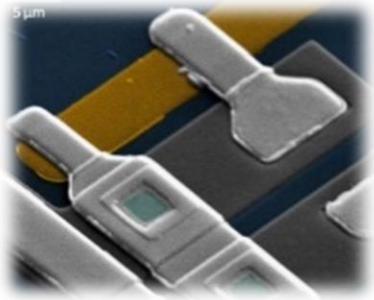


DRD7.6

Common Access to 3D and Advanced Integration

KIT Karlsruher Institut für Technologie

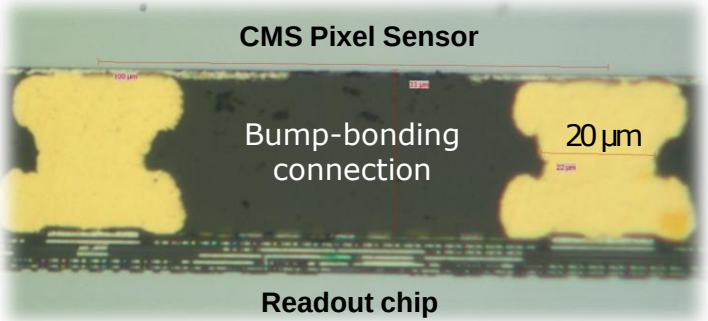
Cryogenic and Semiconductor facility at KIT



Metal Magnetic Calorimeter detector

Facilities

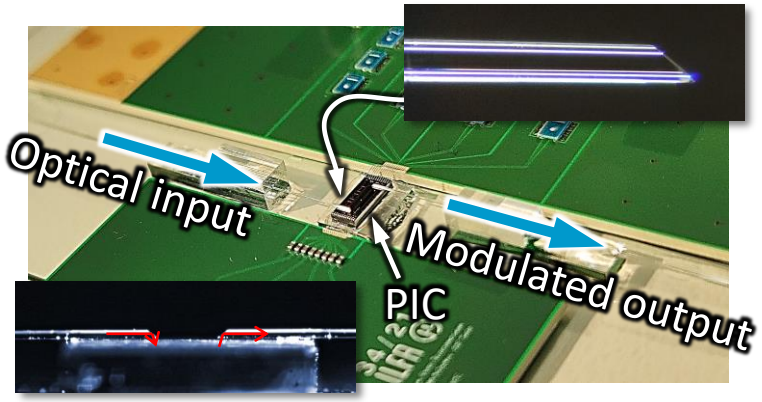
- Dedicated clean room for bump-bonding and detector module production
- *New* clean room, 1000 m^2 from 2025/26 for the production of metallic magnetic calorimeters (MMC) / cryo detectors, packaging and optical lab



Cross-section, CMS pixel detector

Technologies

- Fine-pitch bump-bonding technology based on stud ball bumping
  - Low-cost, fast-deposition, short setup time ideal for single die (i.e. fast prototype R&D)
- 2D bumping technology for HEP, photon sciences and space detectors
- Chiplet, active/passive interposer technologies for detectors
- Wafer level (ICP-RIE, ICPECVD, laser-lithography, UHV-Sputtering, etc.)
- Integration of silicon photonic chips on detector
- Integration of optical fiber on PIC by edge and grating coupling



Courtesy: Marc Schneider

DRD7.6

Common Access to 3D and Advanced Integration

UNIVERSITÉ DE SHERBROOKE

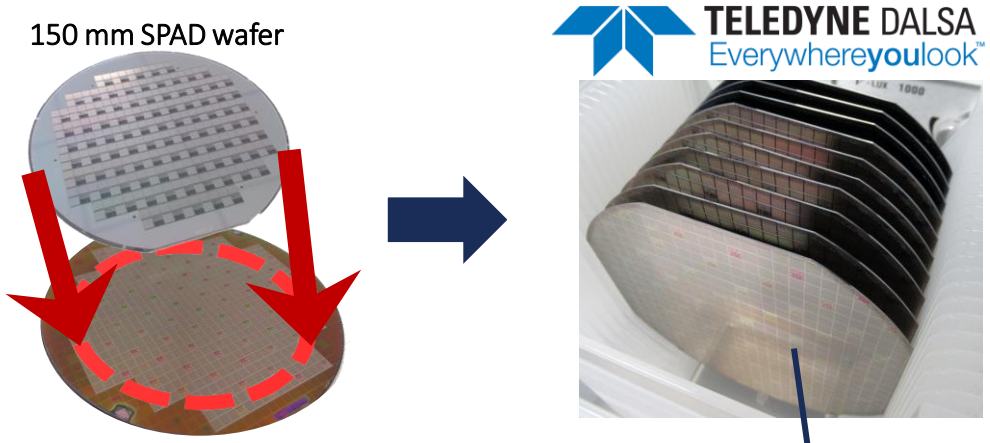
Université de Sherbrooke (QC, Canada) & TRIUMF (BC, Canada)

Technologies required for a complete Photon detection module:

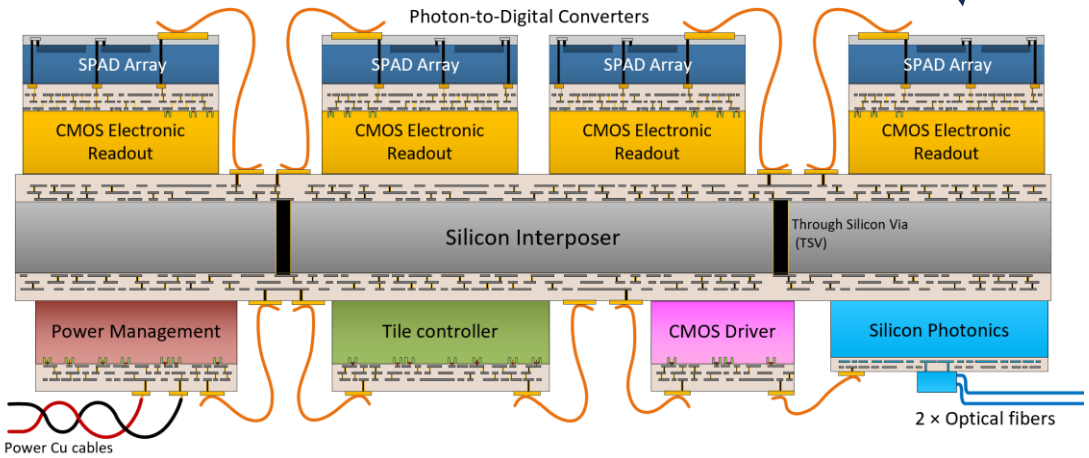
- Teledyne-DALSA (Bromont, QC, Canada): Single Photon Avalanche Diode array and 3D integration
- TSMC (or other foundry): CMOS
- Fraunhofer IZM: Silicon interposer
- AMF : Photonic chip
- University of British Columbia and others: Photonic wire bonding

Currently relying on CMC for chip manufacturing

Courtesy: Fabrice Retiere, Serge Charlebois



The end goal: Photon Detection module

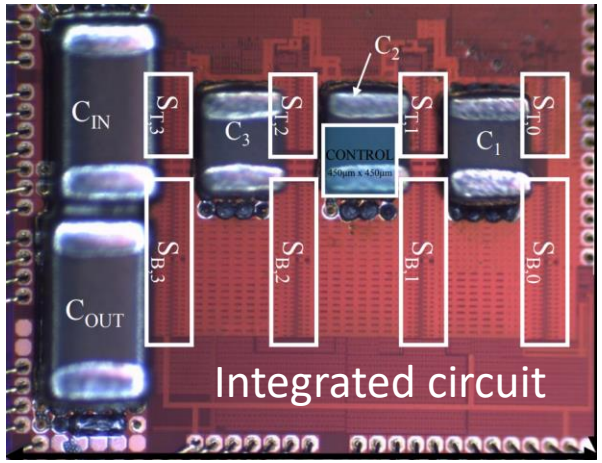


Fachhochschule Dortmund
University of Applied Sciences and Arts

FachHochschule Dortmund

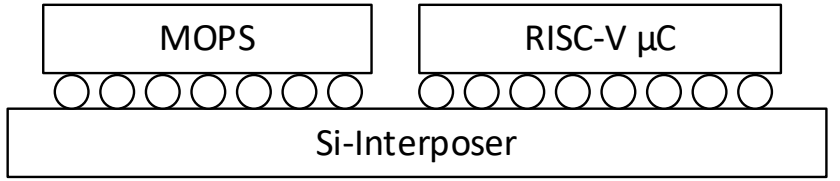
- FH Dortmund is interested in advanced integration techniques with application to
  - power management
  - In-detector intelligence

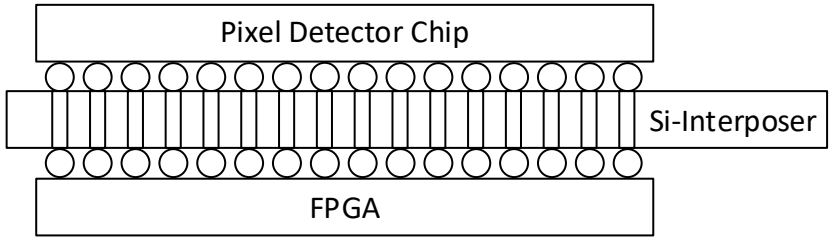
Courtesy: Michael Karagounis



- The following integration techniques will be studied in detail
  1. **Passives on chip/die**
     A power management IC will be equipped with capacitors and/or inductors
  2. **Silicon-Interposer based 2.5D integration** (→ *Kostas's talk*)
     A radhard monitoring IC will be connected to radhard RISC-V microcontroller
  3. **Silicon-Interposer based 3D integration** *(→ Michael's talk)*
     A state of the art monolithic/hybrid pixel chip will be connected to an FPGA
  4. **FH Dortmund will contribute to mechanical and electrical test & characterization,** mechanical & thermal stress, *signal* integrity, …

Monitoring of Pixel System (MOPS)





Impact

- Providing the access via research centers
  - Enable low-cost and direct investigation on critical technologies
  - Funding including personnel confirmed, commitment with 5.5 FTE/year

- Providing the access via vendors / services (DALSA, Ziptronix/Tessara, EVGroup, IZM, and more…)

- Supporting the mechanical and electrical characterizations of chiplet and wafer stacking technologies and integration with SiPh device

➔ Get in touch if you would like to join the list

Thank you for your attention

Institutes involved

Institute	Infrastructure	Expertise/Competence
HLL-MPG	New clean room for detector production equipped with full 200 mm wafer process	DRIE, PECVD and electroplating Cu deposition, direct wafer -bonding technologies, 2.5 D integration including Si interposer with three metal layers, RDL in Cu, and fine-pitch flip-chip
Uni Sherbrooke	3D integration by Teledyne DALSA	AlGe eutectic bonding (435°C) at 150mm and 200mm wafer size (DALSA). Cu-Cu hybrid bonding (Ziptronix/Tessara) on 200 mm wafer
FH Dortmund	Thermostream climate device	Analog, Digital, Mixed-Signal Design. Validation of chips and modules
KIT	Dedicated clean room for detector production	Flip-chip, 2.5 D technology, Au-stud bumping, SiPh design and integration with detectors