Low-Cost Bump-Bonding Processes for High Energy Physics Pixel Detectors

Karlsruhe Institute of Technology

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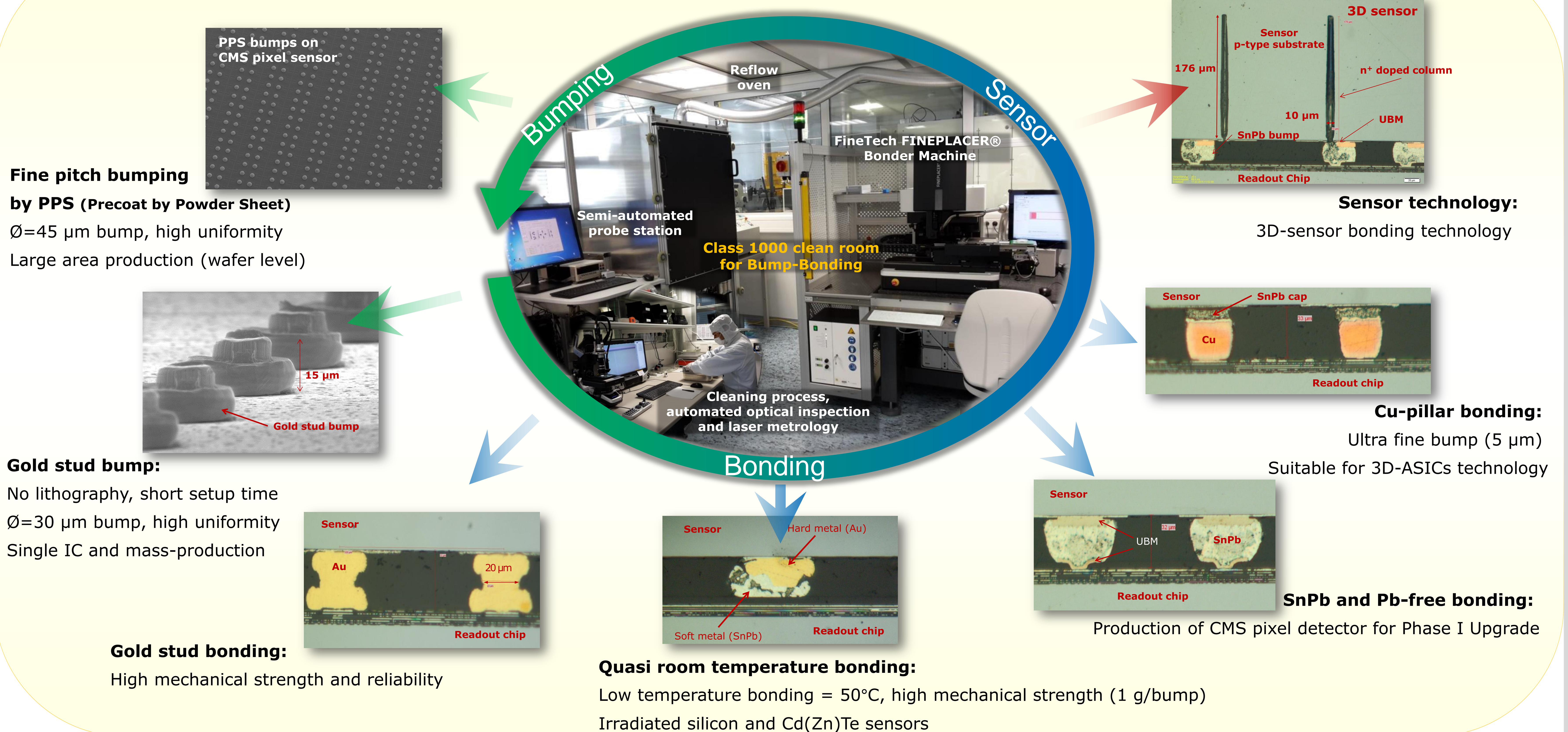
Hybrid pixel technology - competences



Fine pitch bumping by PPS (**Precoat by Powder Sheet**)
Ø=45 µm bump, high uniformity
Large area production (wafer level)

Gold stud bump:
No lithography, short setup time
Ø=30 µm bump, high uniformity
Single IC and mass-production

Gold stud bonding:
High mechanical strength and reliability

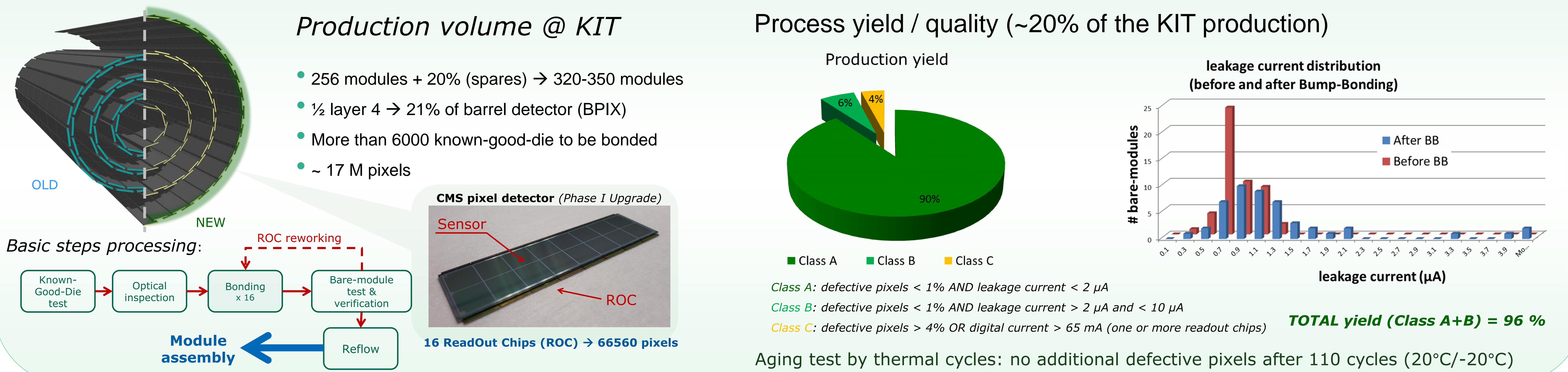
Quasi room temperature bonding:
Low temperature bonding = 50°C, high mechanical strength (1 g/bump)
Irradiated silicon and Cd(Zn)Te sensors

Sensor technology:
3D-sensor bonding technology

Cu-pillar bonding:
Ultra fine bump (5 µm)
Suitable for 3D-ASICs technology

SnPb and Pb-free bonding:
Production of CMS pixel detector for Phase I Upgrade

Bump-Bonding of CMS pixel detector – Phase I Upgrade



Production volume @ KIT

- 256 modules + 20% (spares) → 320-350 modules
- ½ layer 4 → 21% of barrel detector (BPIX)
- More than 6000 known-good-die to be bonded
- ~ 17 M pixels

Process yield / quality (~20% of the KIT production)

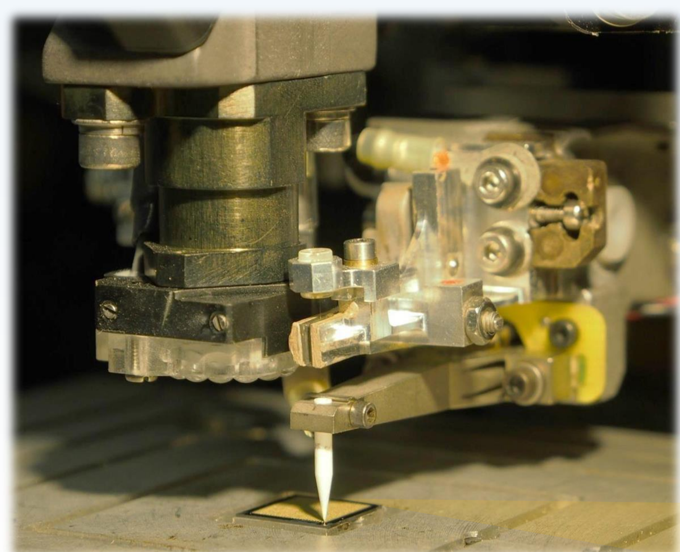
Class A: defective pixels < 1% AND leakage current < 2 µA
Class B: defective pixels < 1% AND leakage current > 2 µA and < 10 µA
Class C: defective pixels > 4% OR digital current > 65 mA (one or more readout chips)

TOTAL yield (Class A+B) = 96 %

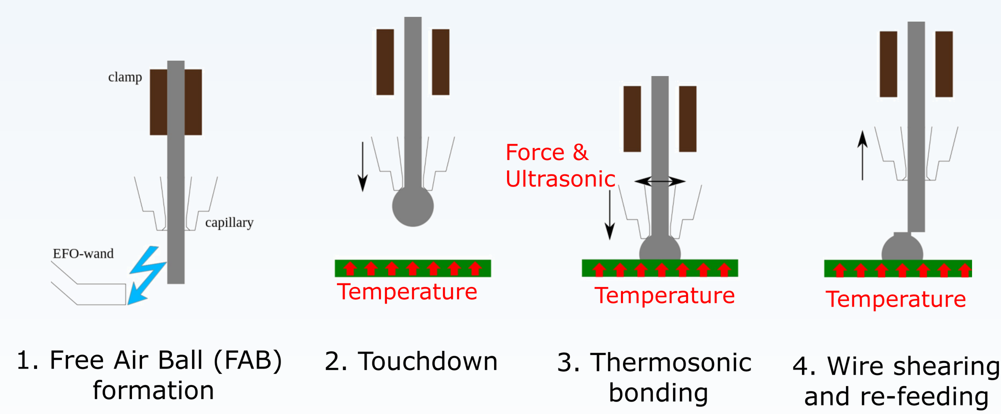
Aging test by thermal cycles: no additional defective pixels after 110 cycles (20°C/-20°C)

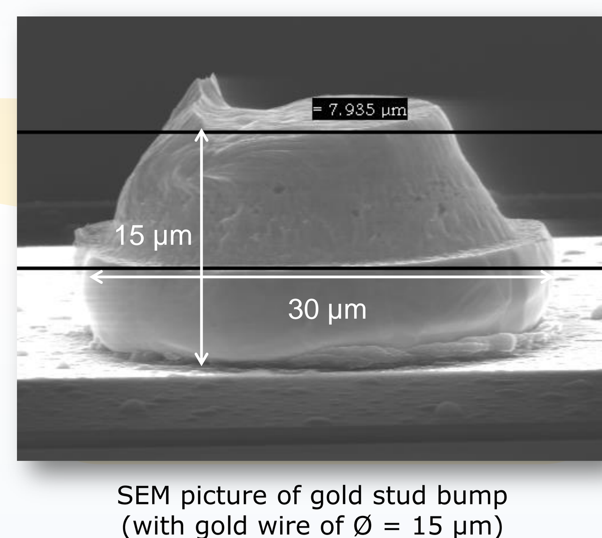
Bump-Bonding of CMS tracker detector – Phase II Upgrade

Bumping process



Kulicke & Soffa® - IConn ball-wedge bonder





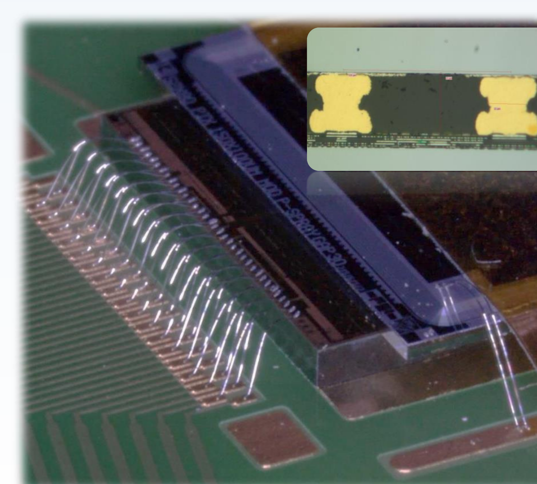
SEM picture of gold stud bump (with gold wire of Ø = 15 µm)

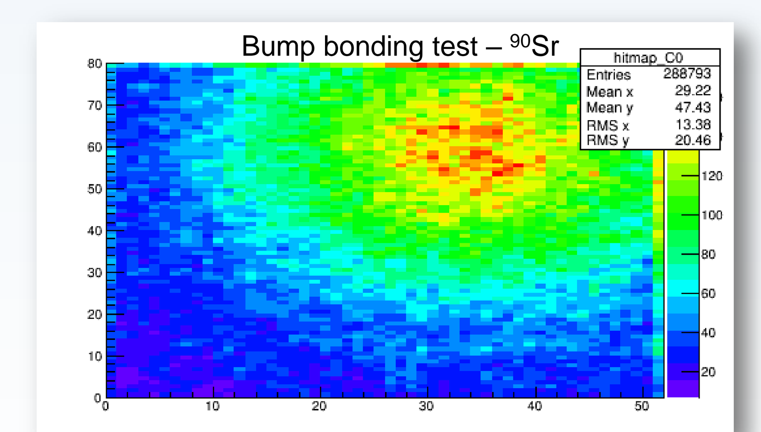
Bumping benefits:

- ✓ **Fast deposition** → 20 bumps/s
- ✓ **Short setup time** → ideal process for prototyping and R&D
- ✓ **High reliability & bump shape uniformity** → ~ few microns
- ✓ **Fine pitch** → minimum pitch of 30 µm (gold wire of Ø = 12,5 µm)
- ✓ **Low-cost bumping process** → direct deposition on Al pad (no lithography)
- ✓ **High mechanical strength** → ~ 9 g/bump (shear test) for Ø = 30 µm bump

Bonding process

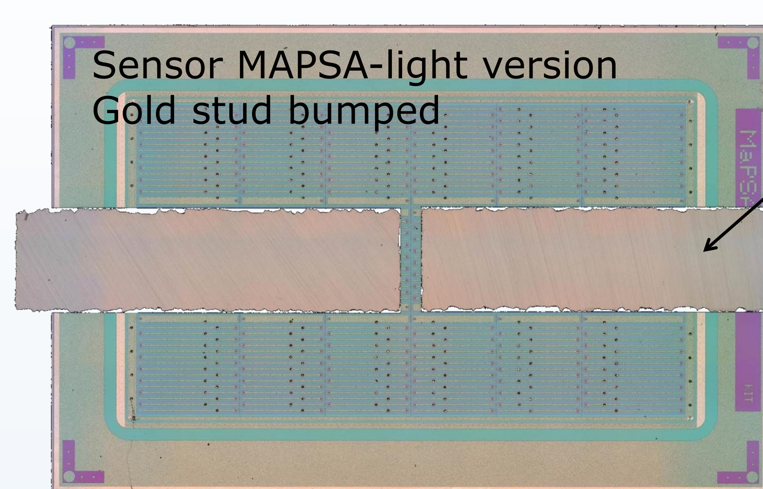
Sensor R&D





High interconnection yield = 99.95 %

Bonding of MAPSA (MAcro Pixel Sub Assembly)



MPA (MacroPixelASIC) readout chip light version

MAPSA pixel detector bonded @ KIT

Gold stud Bump-Bonding suitable for MAPSA
Process setup-time → one week
Electrical test foreseen @ CERN

KIT – University of the State of Baden-Wuerttemberg and National Laboratory of the Helmholtz Association

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