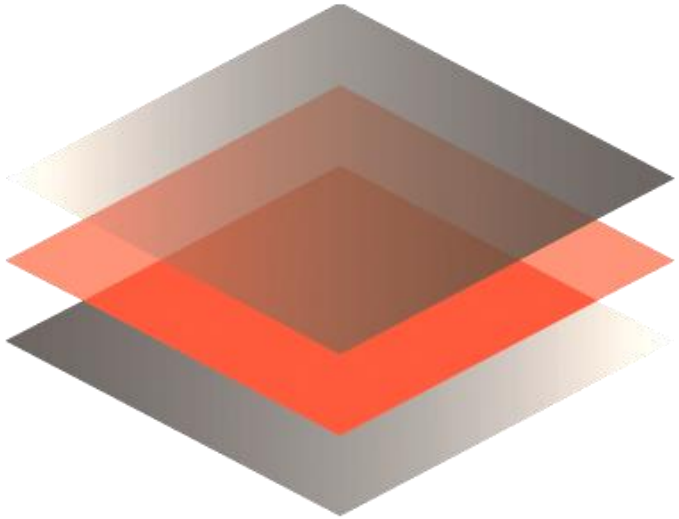
NHanced Semiconductors



Aug 1, 2024

Robert Patti

rpatti@NHanced-semi.com

630-561-6813

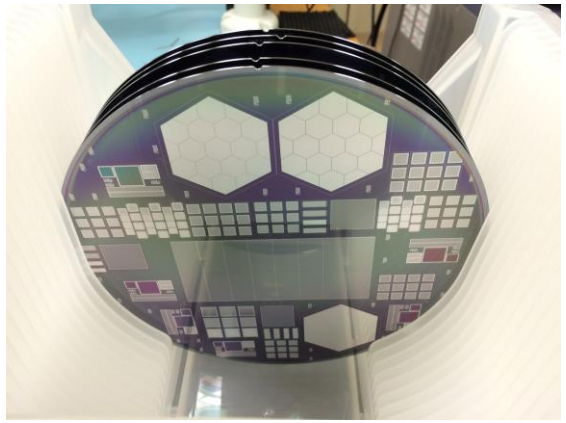
NHanced SEMICONDUCTORS

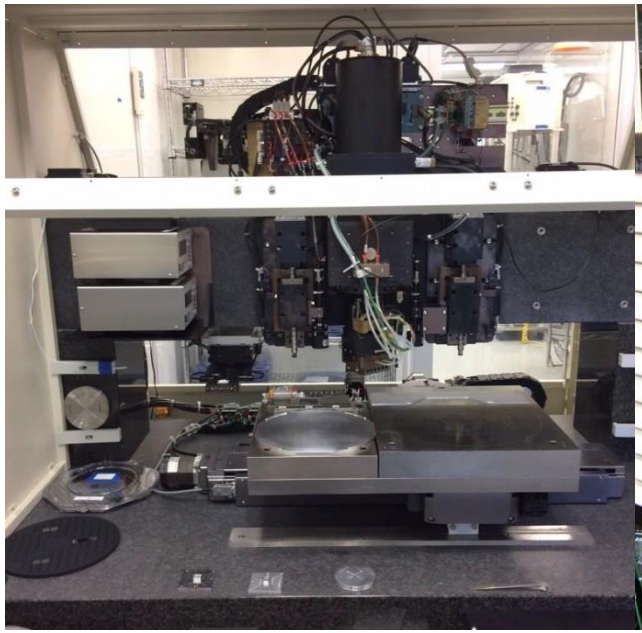
NHanced Background

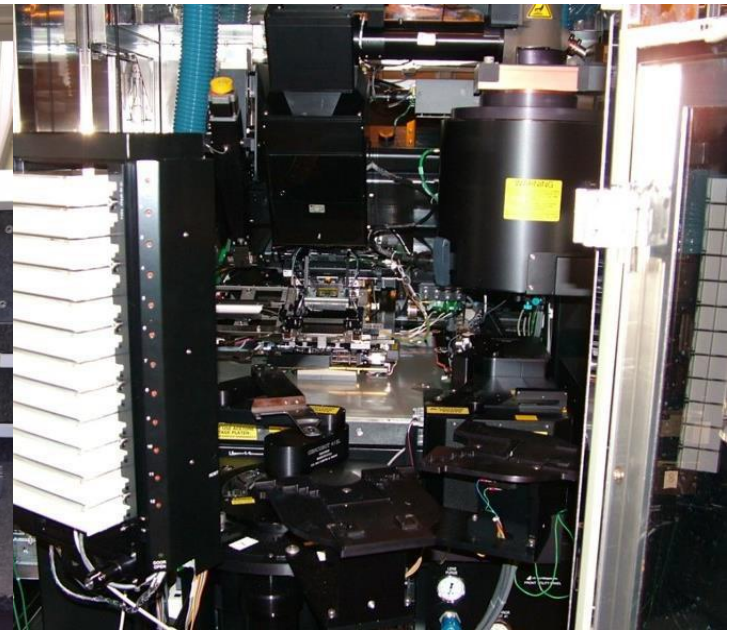
- We target specialty niche markets with Advanced Packaging, Additive Manufacturing, and specialty BEoL:
  - Photonics
  - Fluidics
  - True Heterogenous Integration
  - RadHard
  - Quantum devices
  - FPGAs
  - Memory including ReRAM, MRAM, FeRAM, EEPROM, DRAM, SRAM
  - AI/ML/Exascale
  - RFID
  - Medical
  - Down-hole to deep-cryo
- Mixed commercial and A&D customers and production
- 80 employees
  - Deep technical bench with industry recognized experts on staff.
  - Core team has worked together for >20 years
  - Industry awards for advanced packaging
- Tightly held US ownership

NHanced Semiconductors

- Batavia, IL: Design and Test
  - Complete front end and back end design down to 12nm
  - Supports AI and HPC systems development
- Morrisville, NC: Foundry 1
  - 50mm to 200mm wafers
  - Copper, Al, Ni BEoL
  - Interposers
  - 2.5/3D Integration
  - W2W, D2W
- Morrisville, NC: Foundry 2&3
  - HVM AP 200mm 2025
  - HVM AP 300mm 2026
- Odon, IN: Packaging
  - Packaging
  - RadHard Microelectronics
- Odon, IN: Interposer Foundry 4
  - HVM 1.5M/yr
  - In buildout – 1Q2025 start





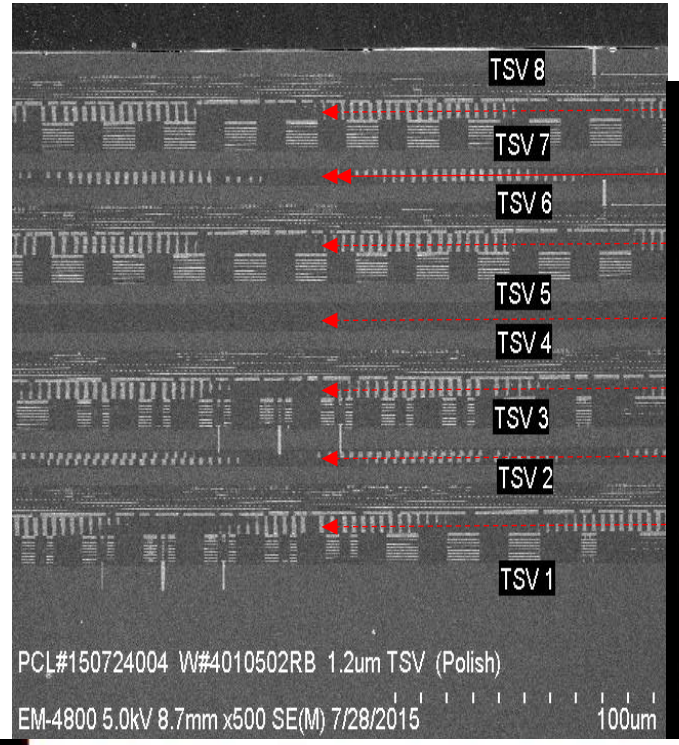


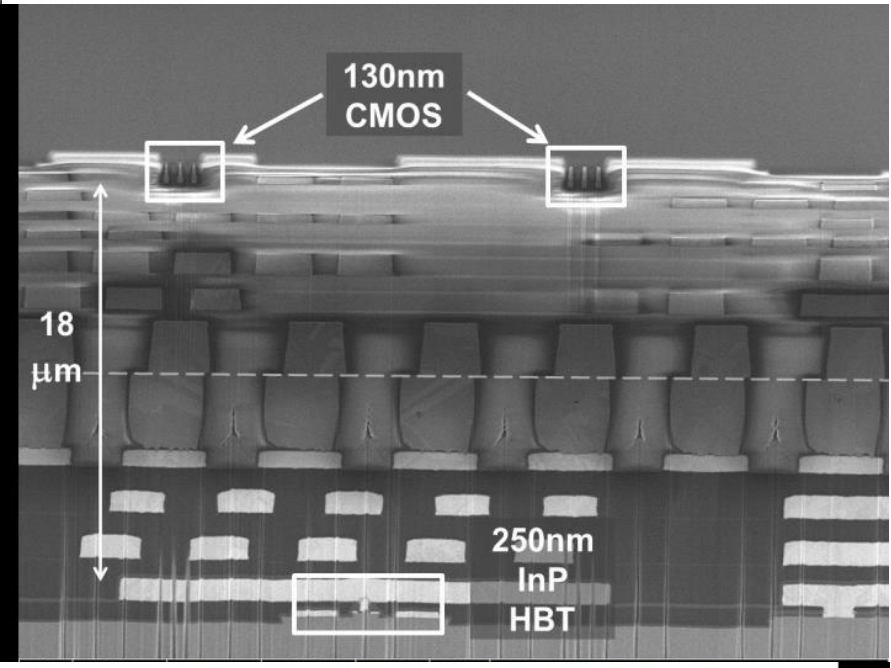
New Tools and Capabilities - Highlights

- Die to Wafer Bonder
  - Besi Next Gen
  - Better than 200nm accuracy
  - >2k die per hour
  - >three 9s going to five 9s
- Bosch Etch
  - PlasmaTherm
- Oxide/Nitride
  - Trion
  - Low temperature – down to 70C oxides
  - Stress balanced
- Pd/Au Plating
  - Quantum device enablement
- Large TSV Fill
  - 50x300um, 25x200um
- New Oxide Etch
  - AMAT P5000
- New PVD
  - Endura 5500
- New Metrology
  - Next gen ultrasound
- New Production Plater
  - Raider
- New ALD
  - Arradiance
  - High aspect ratio TSV barrier and seed
  - High k thin films
- I-Line 1x litho
  - NXQ8000
  - Full wafer reticle – stitchless interposers to full wafer size
  - Near I-line stepper performance: 1um L/S
  - Through wafer IR alignment

AP Services: Bonding

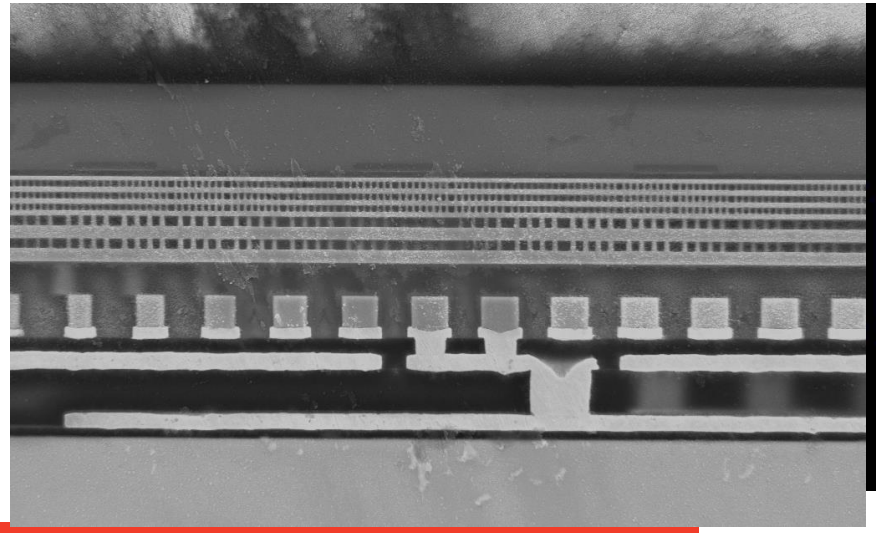
- High maturity
- Up to 20 tiers
- True heterogenous with micron scale interconnects
- Die-to-wafer, wafer-to-wafer

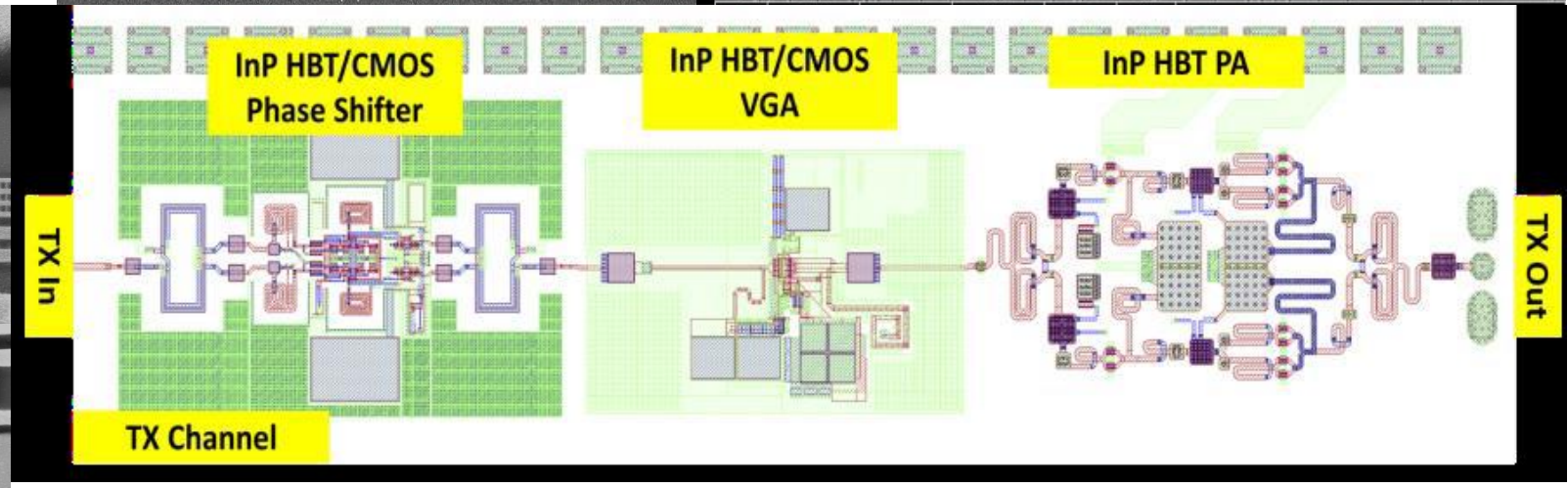




Mixed Materials

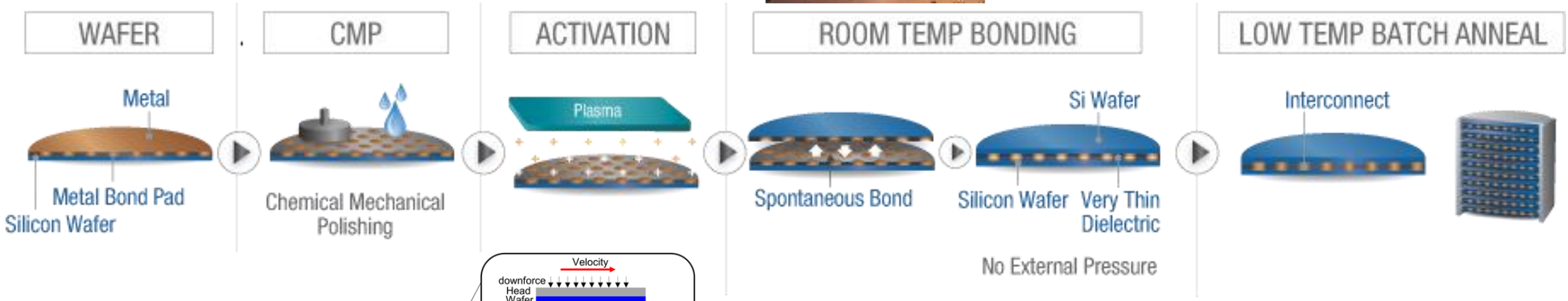
Best of Class

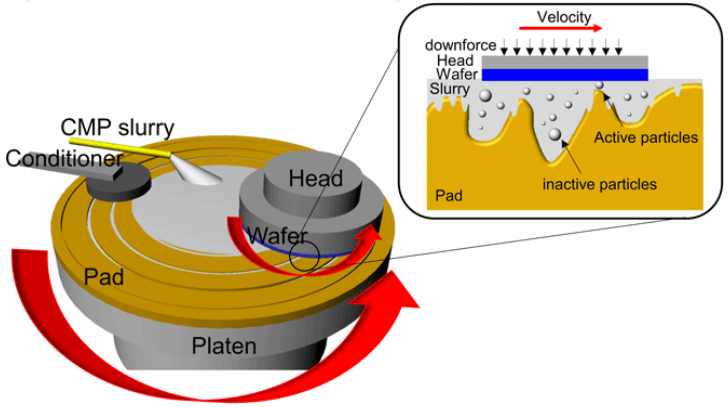


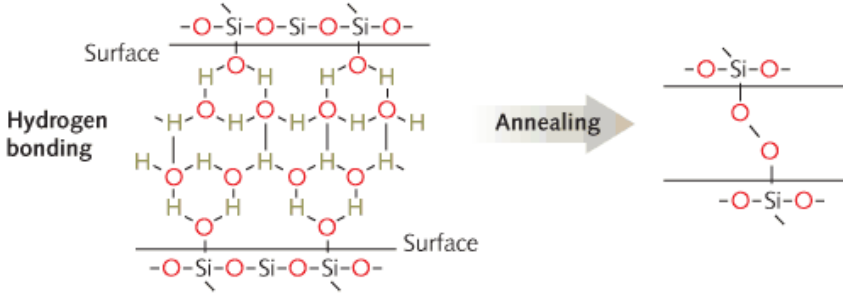


NHanced SEMICONDUCTORS

DBI®: Low Temperature Hybrid Bonding Process



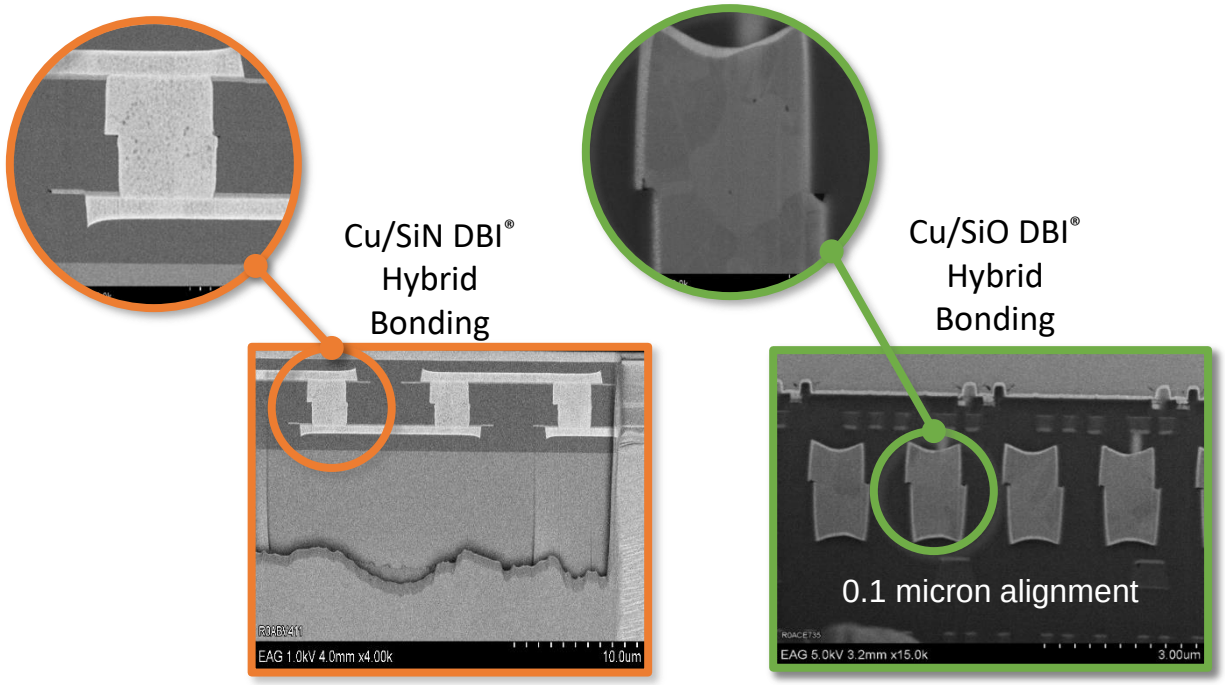




Jihoon Seo / Materials Research Society

NHanced SEMICONDUCTORS

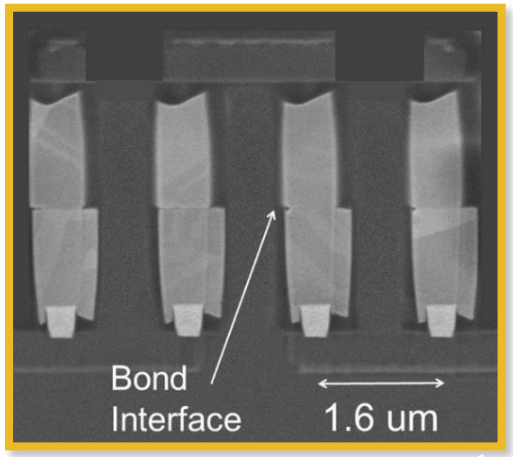
Hybrid Bonding Interconnect Pitch Scaling



10 µm DBI® pitch, 300℃

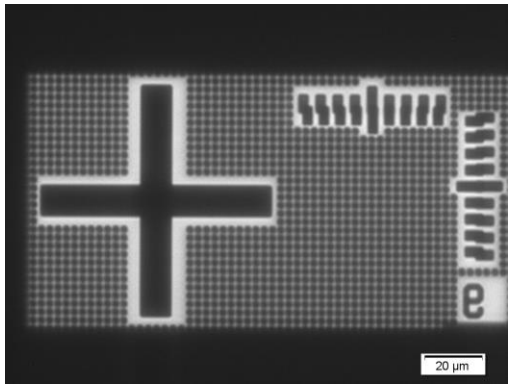
1.9 µm DBI® pitch, 300℃

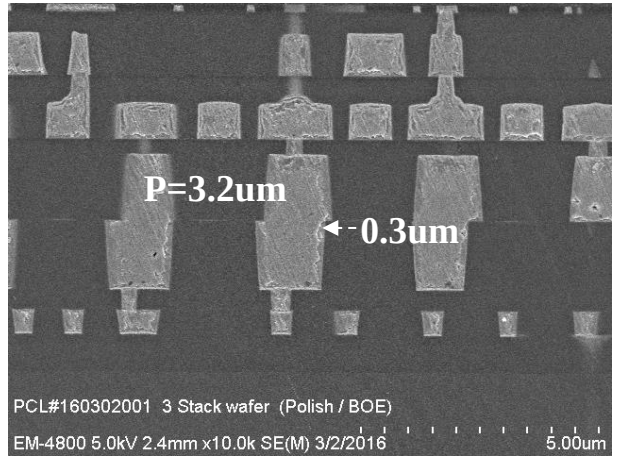
Scalable To < 1um Pitch
0.8um Pitch Demonstrated



1.6 µm DBI® pitch, 300℃

- WtoW 3sigma < ±1um misalign performance
- DtoW 3sigma < ±200nm misalign performance
- Production Minimum pitch = 2.44um



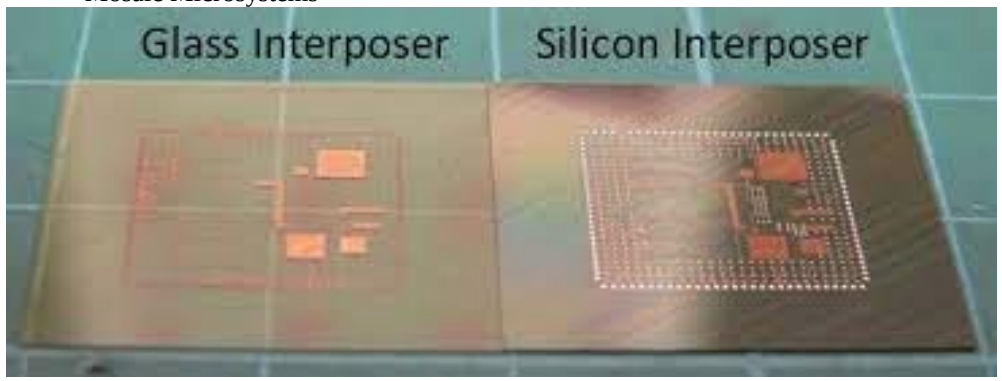


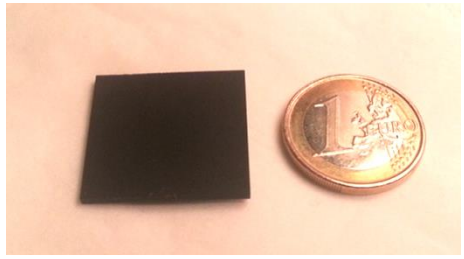
NHanced SEMICONDUCTORS

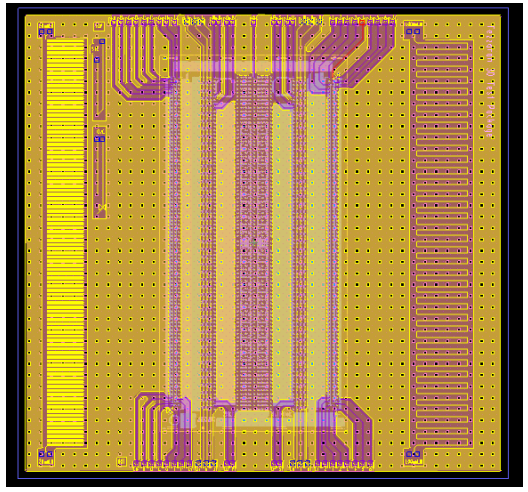
AP Services: Interposers

- Up to full wafer scale
- HP 2um thick wiring is standard

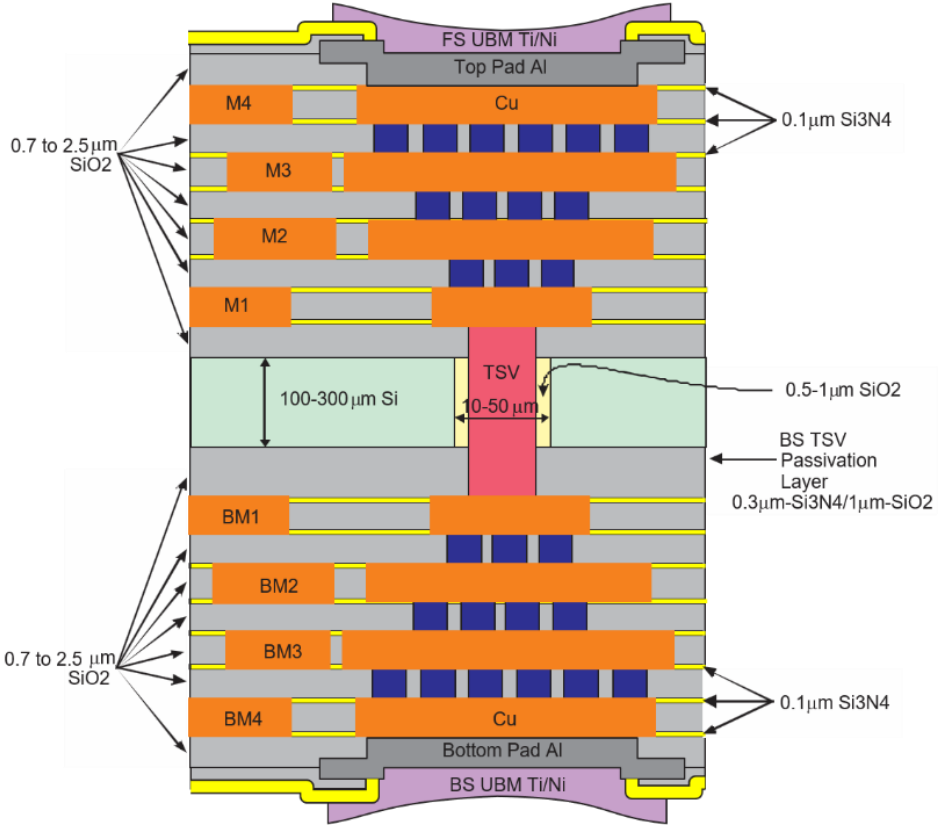
Mosaic Microsystems

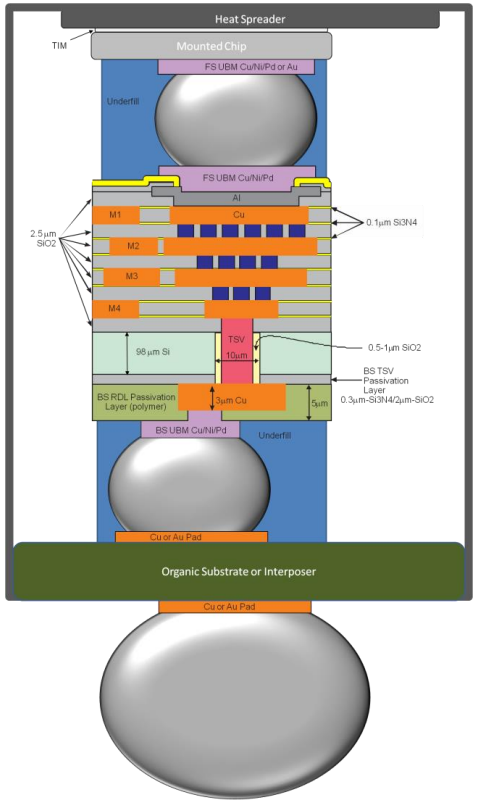






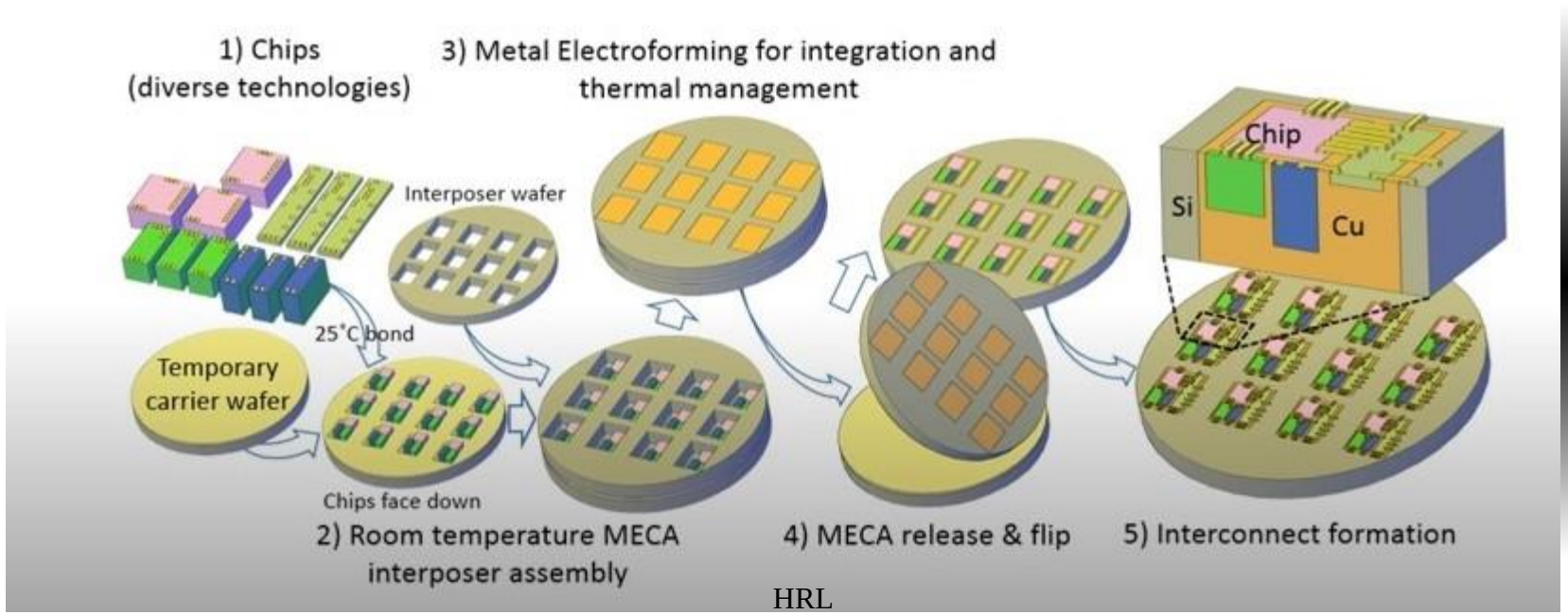
Up to 8 layers of wiring available



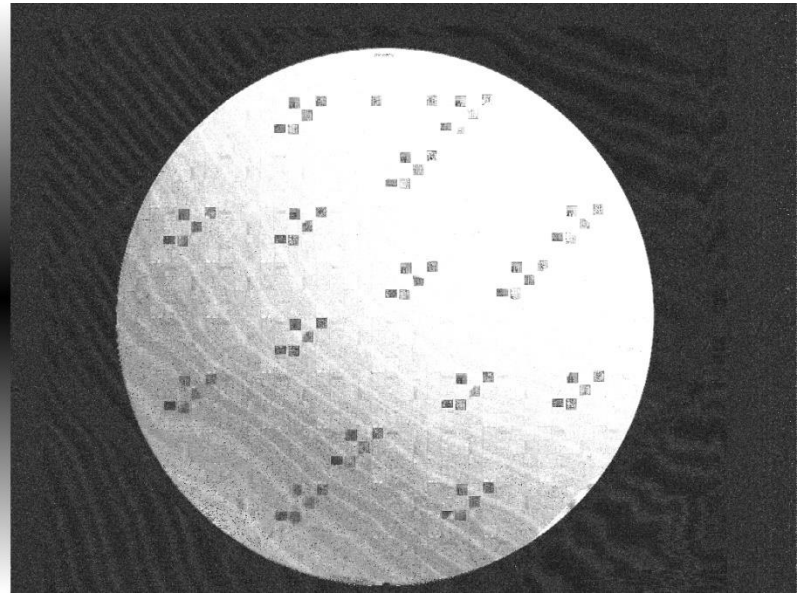


NHanced SEMICONDUCTORS

AP Services: Embedded 2.5/3D — Wafer Reconstitution

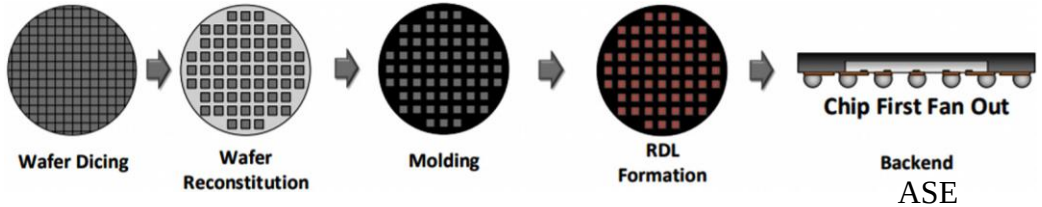


HRL



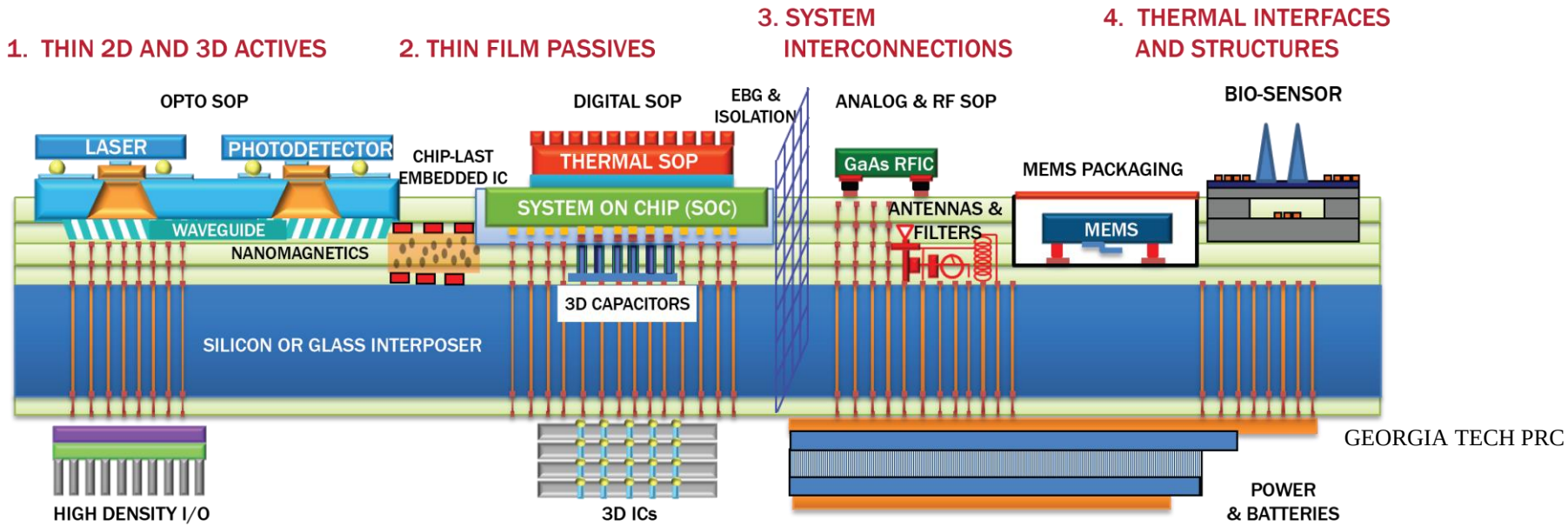
Wafer reconstruction and adaptative substrates provide additional flexibility and next level packaging alternatives.

DECA Technologies

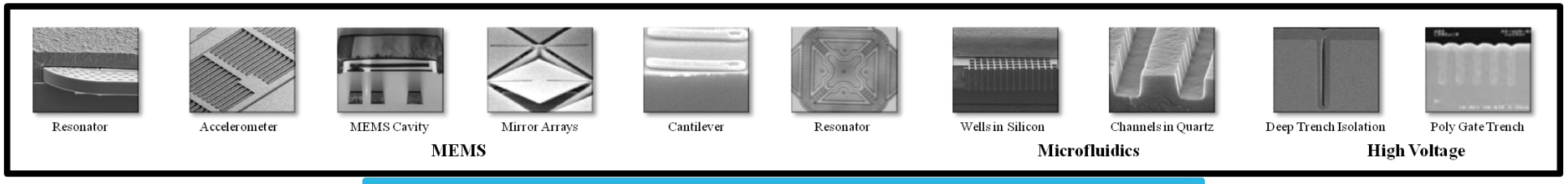


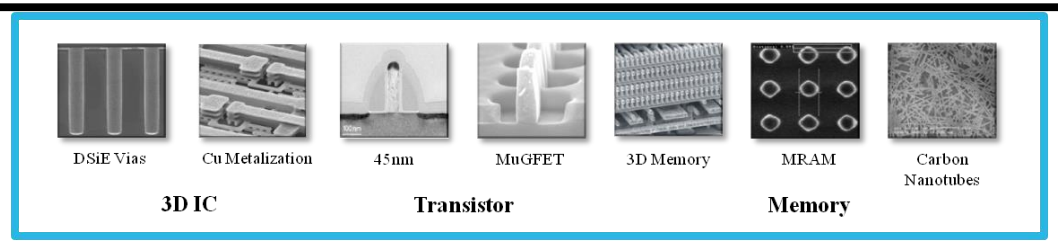
ASE

NHanced Supports Many More Than Moore Technologies



GEORGIA TECH PRC

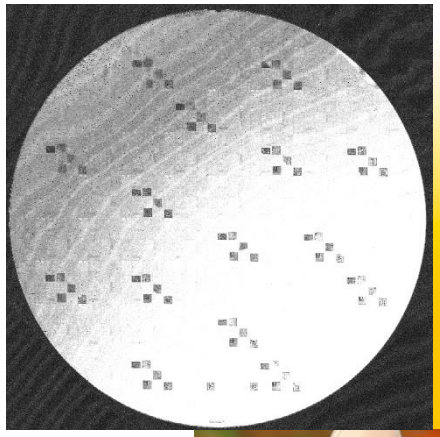


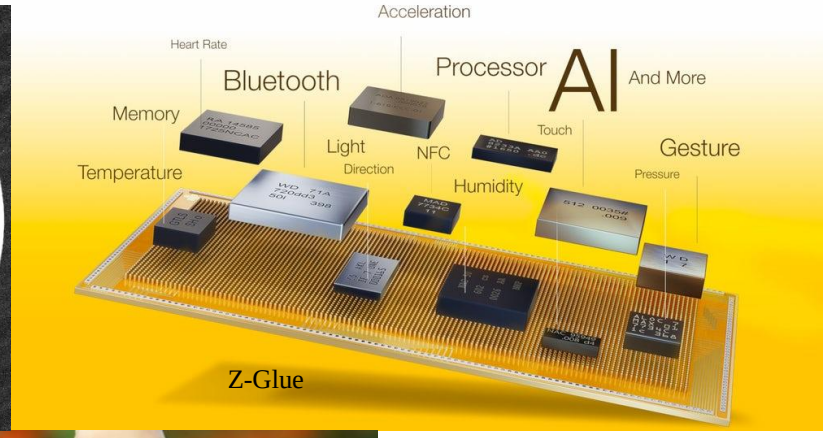


NHanced SEMICONDUCTORS

AP Services: Chiplets

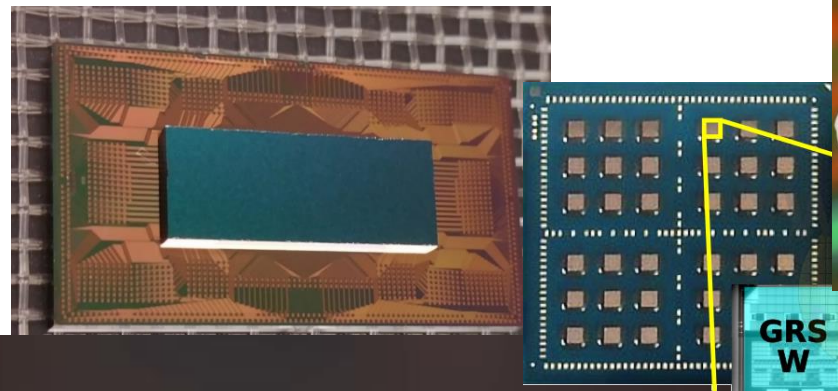
- Provides:
  - Best of Class Everything
  - Easy retargeting
  - Lower risk
  - IP reuse
  - Lower cost

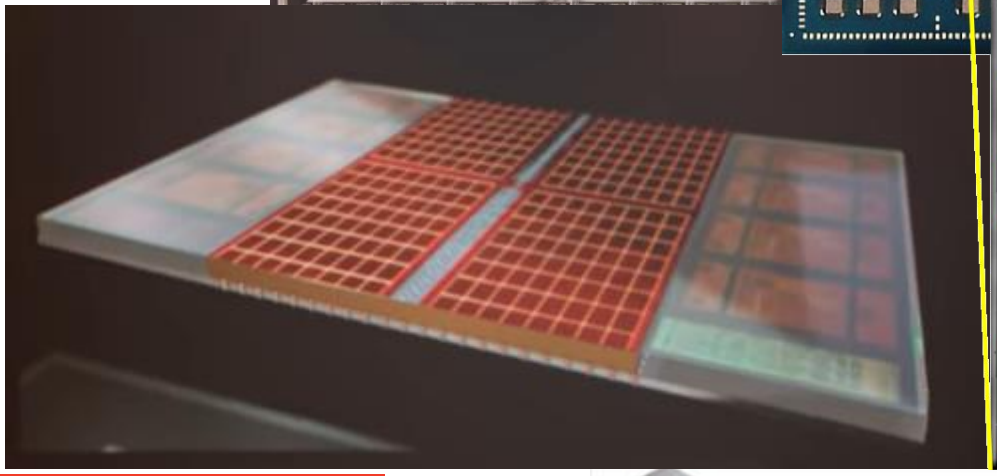




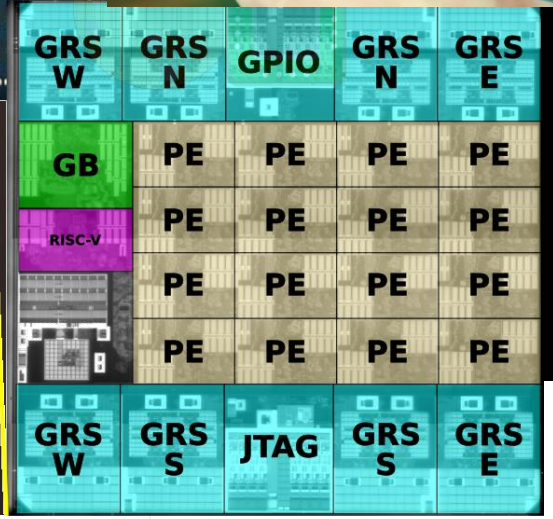
Z-Glue

Intel





AMD



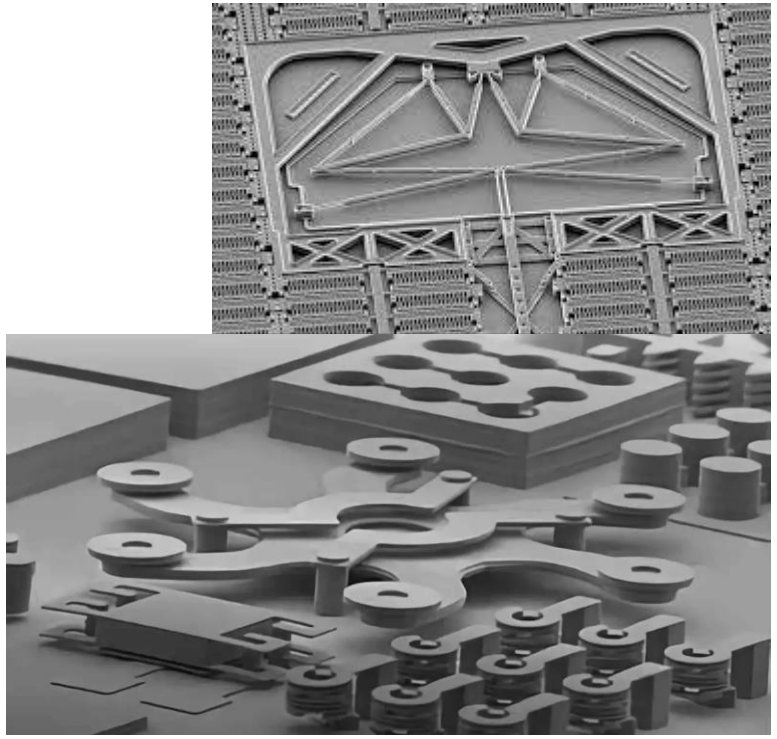
nVidia

Intel

AP Services: Micro-Connections and 3D Structures

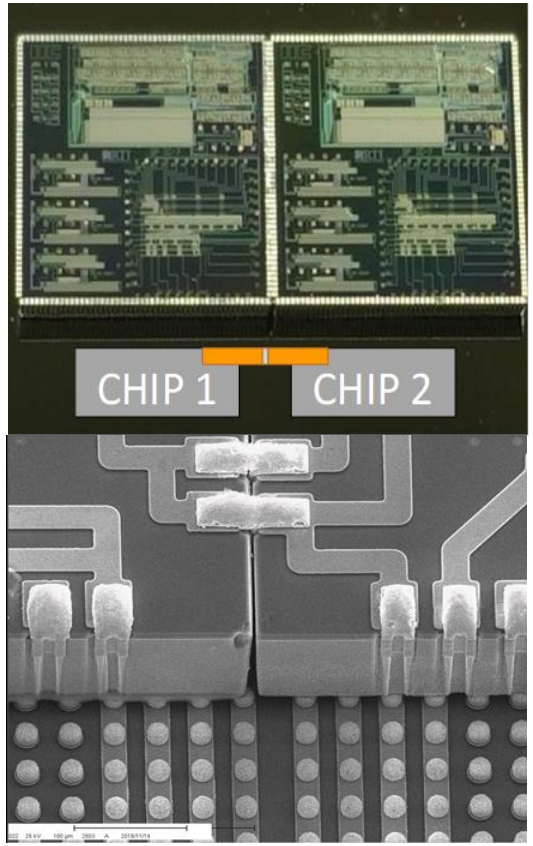
MEMS + Precision Electronics

Bacteria-World



techunwrapped.com

IIC



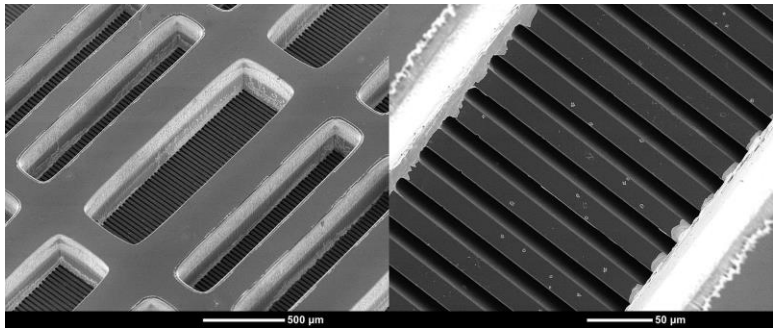
Quilt Packaging concept cross-section illustration & image of a post-reflowed QP CMOS quilt

SEM image of quilted chip-to-chip seam of >10 micron width

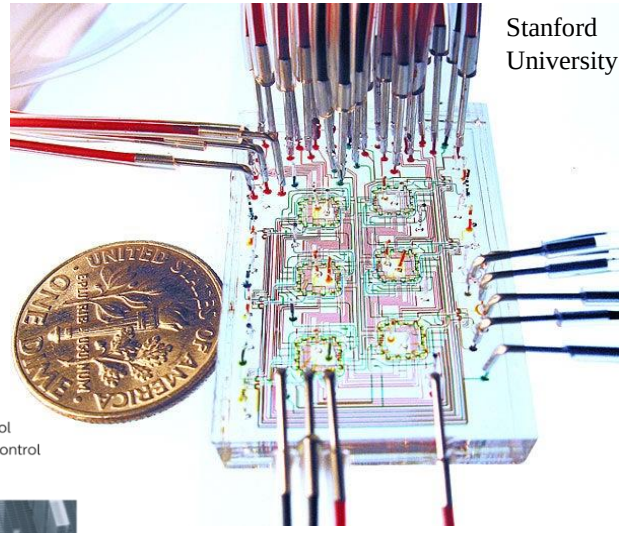
AP Services: Microfluidics and Cooling

Chip Scale Cooling
For Ultra-Dense Electronics

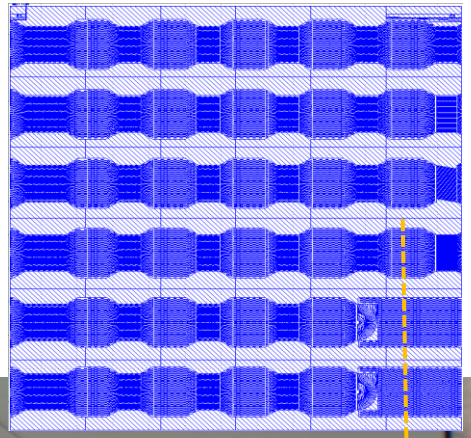
Purdue

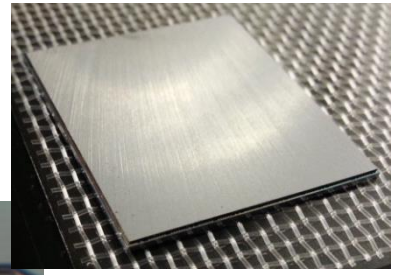


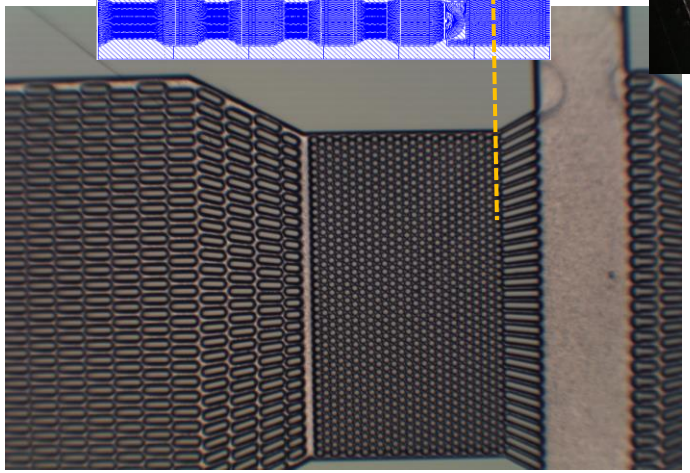
Biology + Electronics



Stanford University

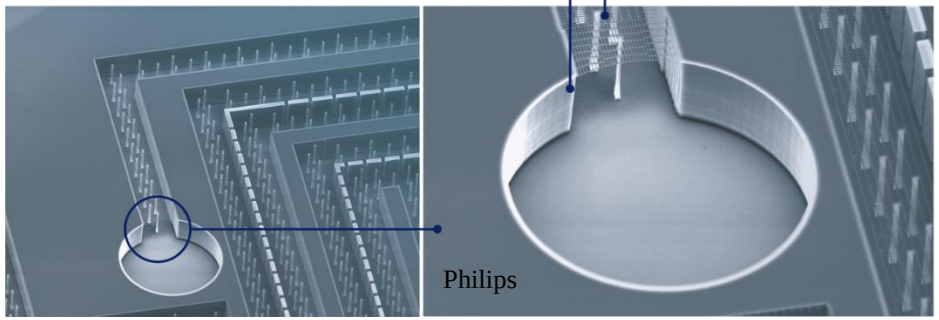






Our state-of-the-art tool set enables us to create microfluidic structures with accurate control:

- <5 degree slope control
- Sub-µm feature size control
- µm range feature size



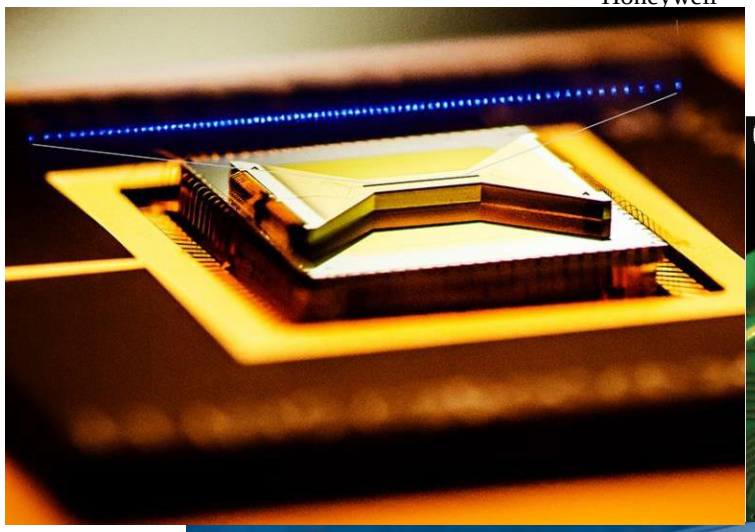
Philips

NHanced SEMICONDUCTORS

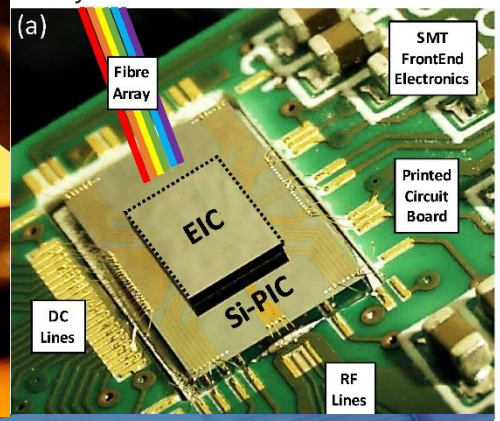
AP Market Drivers: Photonics & Quantum

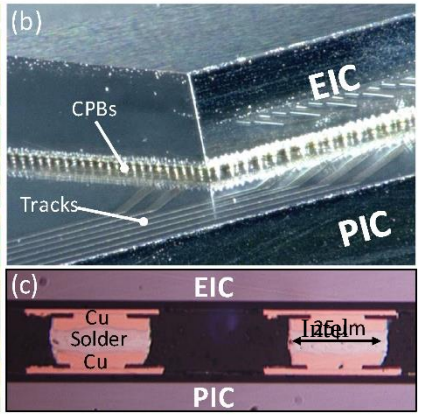
- I/O
  - Tb/s, <<100fJ/b
    - SiP 500ff I/O Load
    - 2.5D 25ff I/O Load
    - 3D 3ff I/O Load
- Processing
  - “Quantum Leaps”

Honeywell

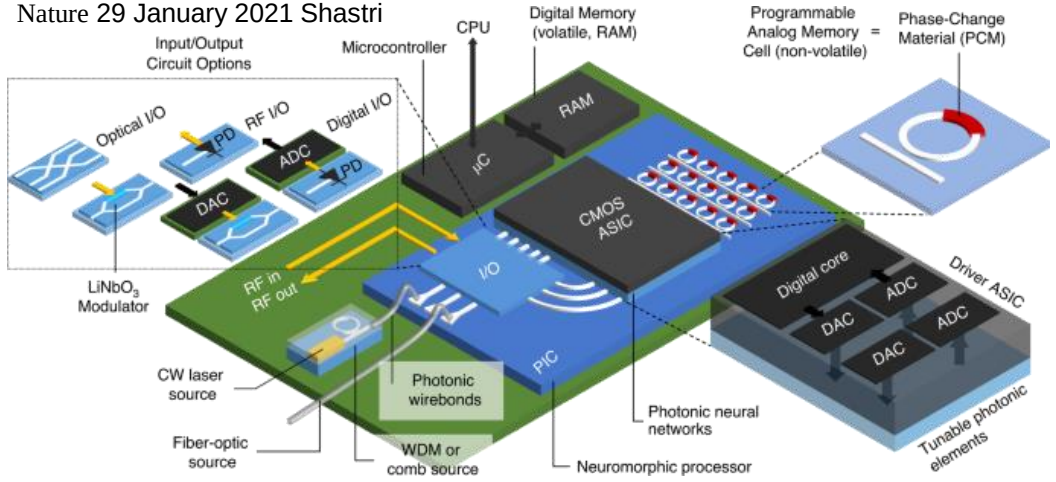


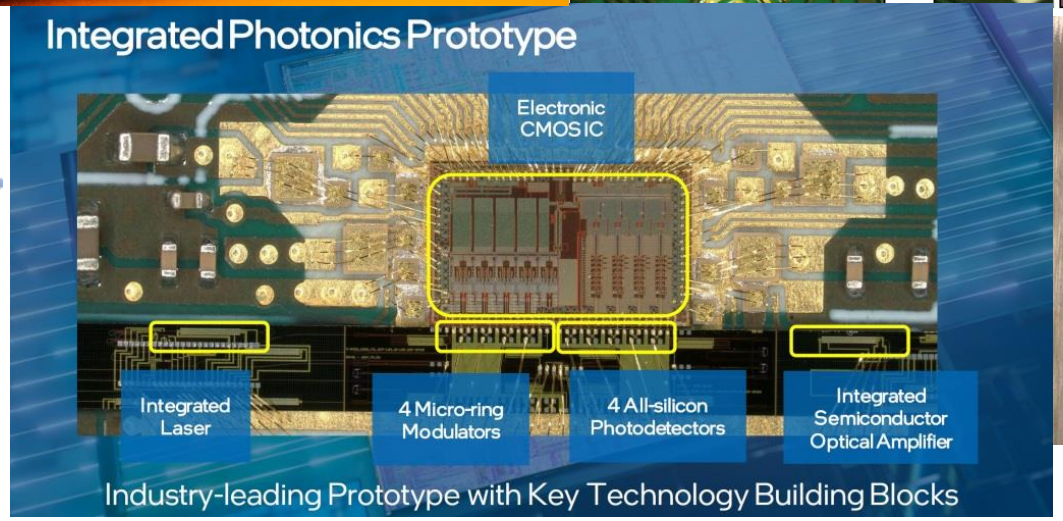
Tyndall National Institute Carroll et al

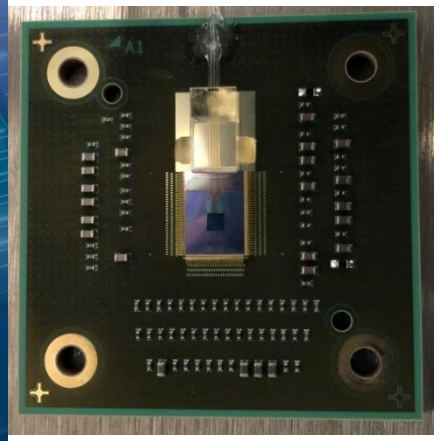




Nature 29 January 2021 Shastri





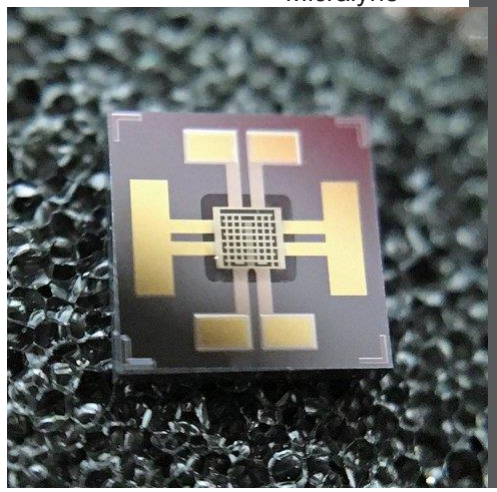


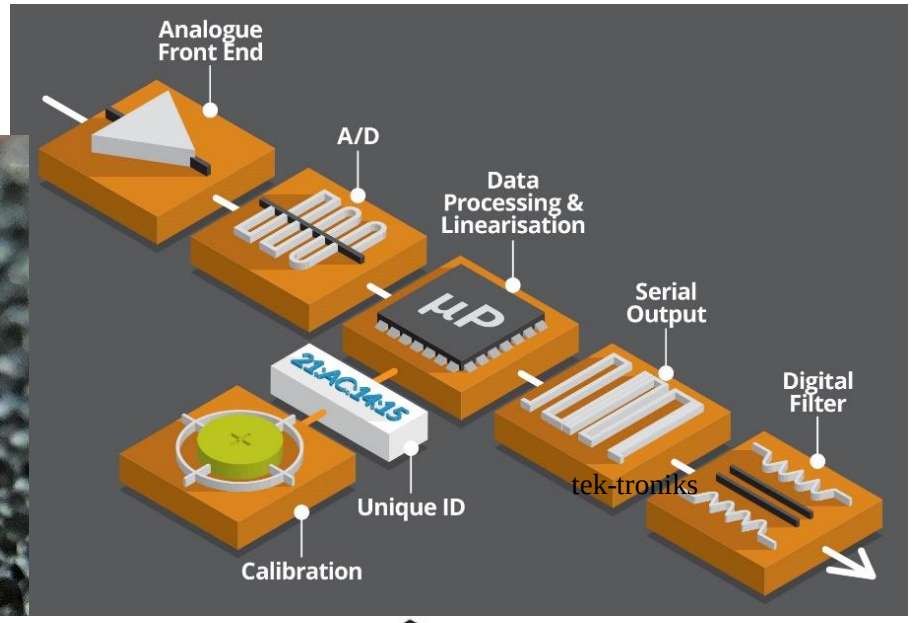
NHanced SEMICONDUCTORS

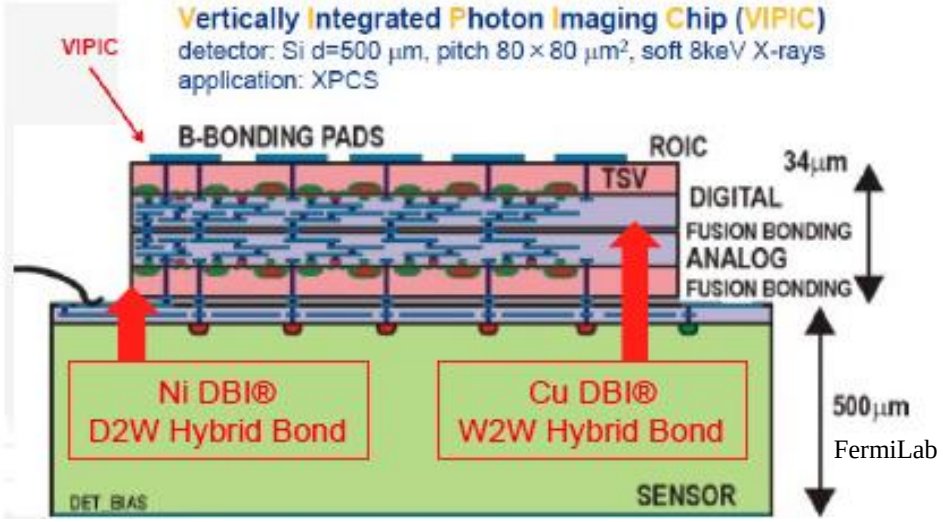
AP Market Drivers: Intelligent Sensors and Edge Compute

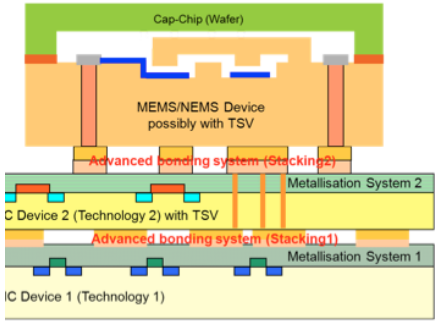
- Communication is limited
  - Data movement costs power
  - Data movement costs time
  - Data movement costs money
  - You can't aways "phone-home"

Micralyne

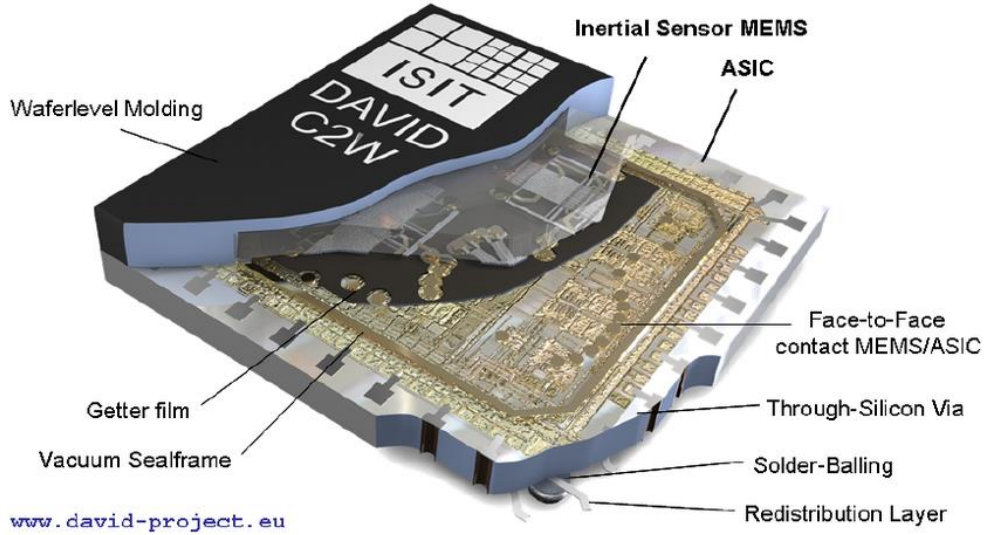






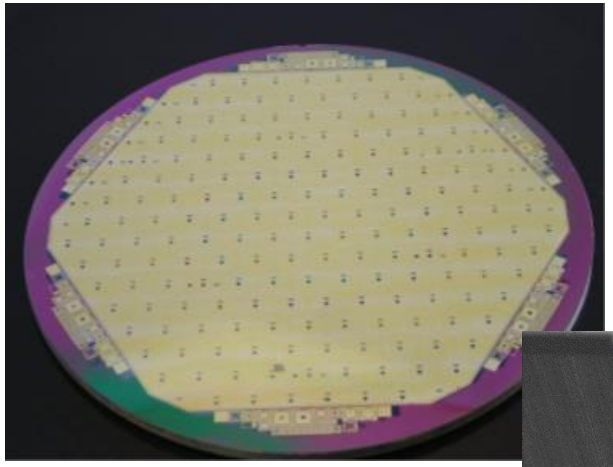


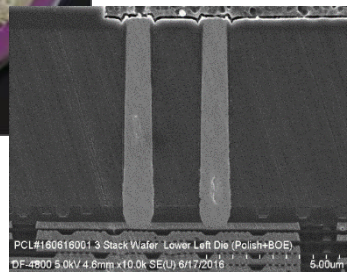
3DinCites

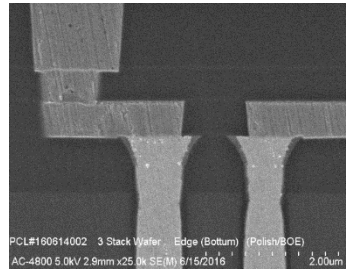


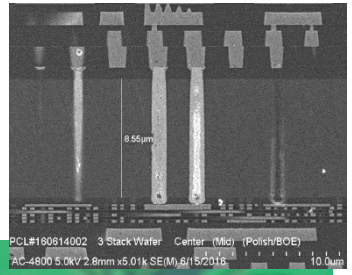
NHanced SEMICONDUCTORS

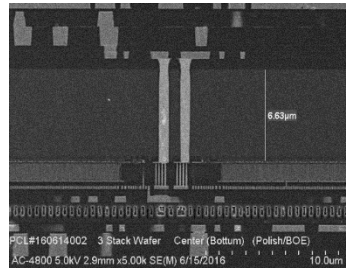
NHanced Small/Medium Scale – High Touch Manufacturing

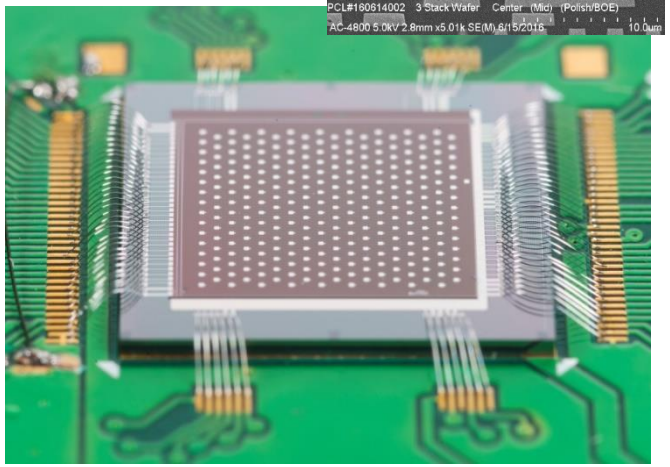












- 2.5/3D Advanced Packaging
- Si Sensors
- Commercial Development
- Mil-Aero Development and Manufacturing
  - Full BEoL
    - Niche BEoL Processes
    - Cu, Ni, Al, +
  - Split-Fab
  - High k-caps
  - ReRAM
  - 3/5 and LiNbO3 integration
  - Thick Wafer & Thin Wafer Processing
- ISO 9001
- CRADA in place for Trust

- Target market is customers needing
  1 to 5000 wafers per year

NHanced SEMICONDUCTORS

NHanced Standard Capabilities

Advanced Packaging:

- HDI edge packaging
- Chiplet integration
- TSV insertion
- Covalent oxide bonding
- Hybrid copper and nickel bonding
  - True heterogeneous integration
- Transfer printing assembly
- Wafer reconstitution
- Die-to-die, die-to-wafer, and wafer-to-wafer 2.5D and 3D integration

Specialized Materials:

- Interposers: silicon, glass, and fused silica
  - Optical and electrical interconnect
- Advanced substrates: silicon, GaN, GaAs, InP, GaSb, LiNbO3, BTO, SiC, etc.

AP Assembly:

- Flip-chip
- Solder ball drop
- Co-packaged optics
- Interposer and substrate