Challenges and Solutions to Failure Analysis in 3D Microsystems

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Why 3D Microsystem FA Development Is Needed?

- Defect localization needed for reliable, high yielding, and lifetime mission requirements
  - SOTA IC manufactures realize/invest for success
- Tools exist for FA of disparate, separate technologies
  - Si ICs, GaAs power, RF, photonics, etc.
  - Largely electron, ion, light, or thermally-based
- Existing tools not sufficient for existing/emerging 3D space
- Defect ACCESSIBILITY is a major issue
  - Stacked components, novel interconnects, and packaging present new FA challenges

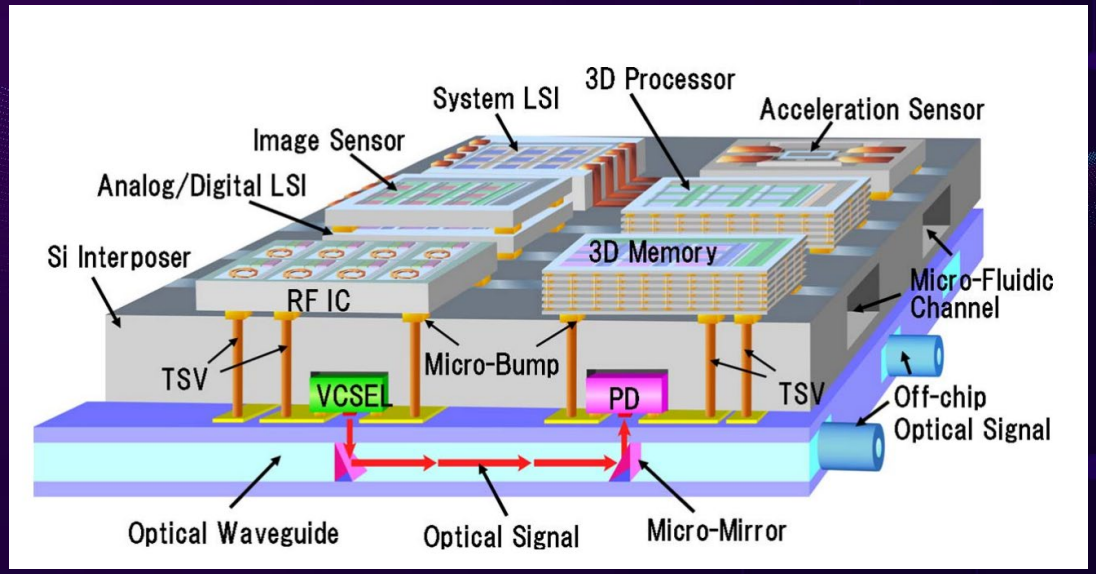
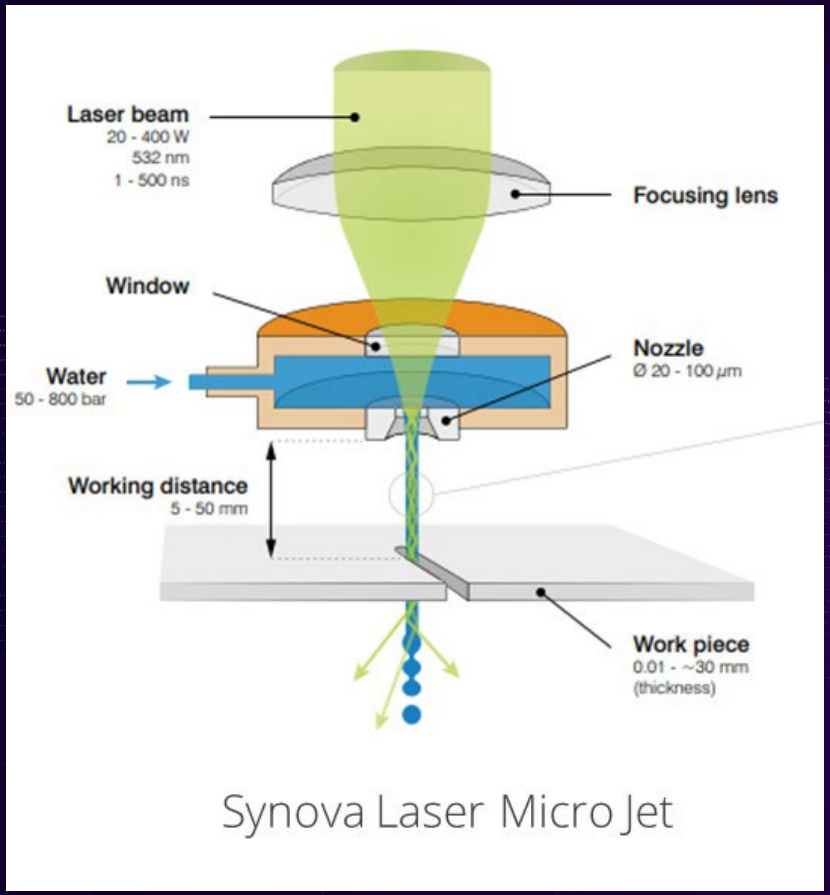


Image from: K. -W. Lee, A. Noriki, K. Kiyoyama, T. Fukushima, T. Tanaka and M. Koyanagi, "Three-Dimensional Hybrid Integration Technology of CMOS, MEMS, and Photonics Circuits for Optoelectronic Heterogeneous Integrated Systems," in IEEE Transactions on Electron Devices, vol. 58, no. 3, pp. 748-757, March 2011, doi: 10.1109/TED.2010.2099870.

How to Meet the 3D Microsystem FA Challenge?

- Continue to leverage existing capability as applicable
  - Testing, JTAG, accessible FA tool targets
- Three major categories for new approach development
  - Take apart
  - Listen
  - Stimulate and listen
- A fourth category would be any combination of these to achieve successful FA
- Maintaining defect integrity without adding ambiguity is an overarching desire

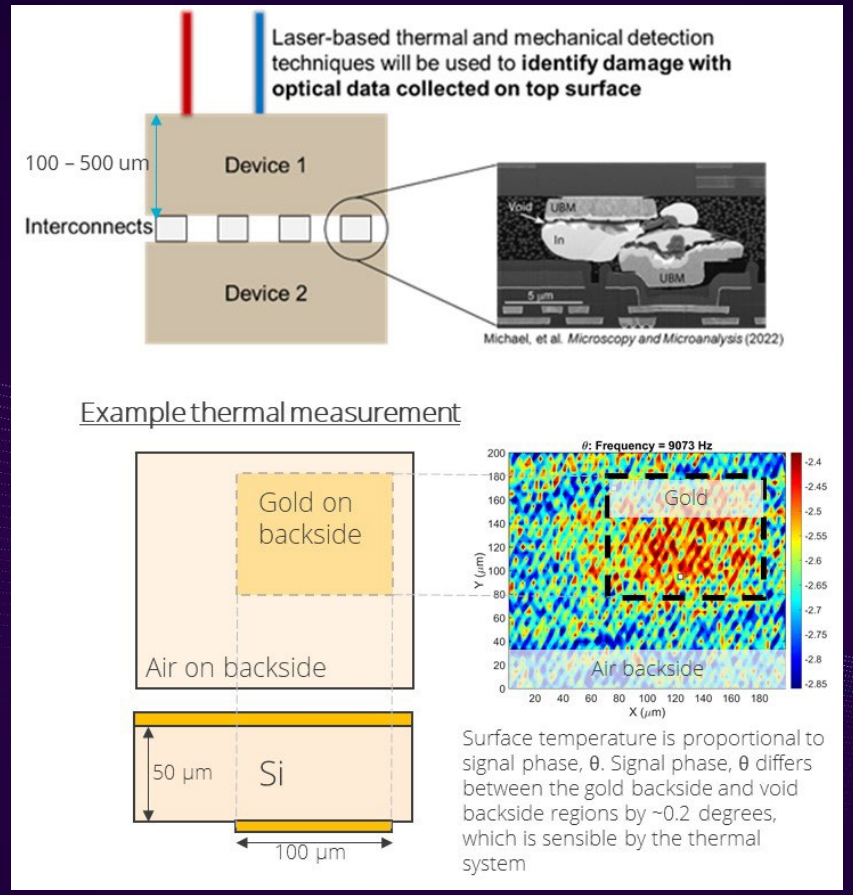
Take Apart



Synova Laser Micro Jet

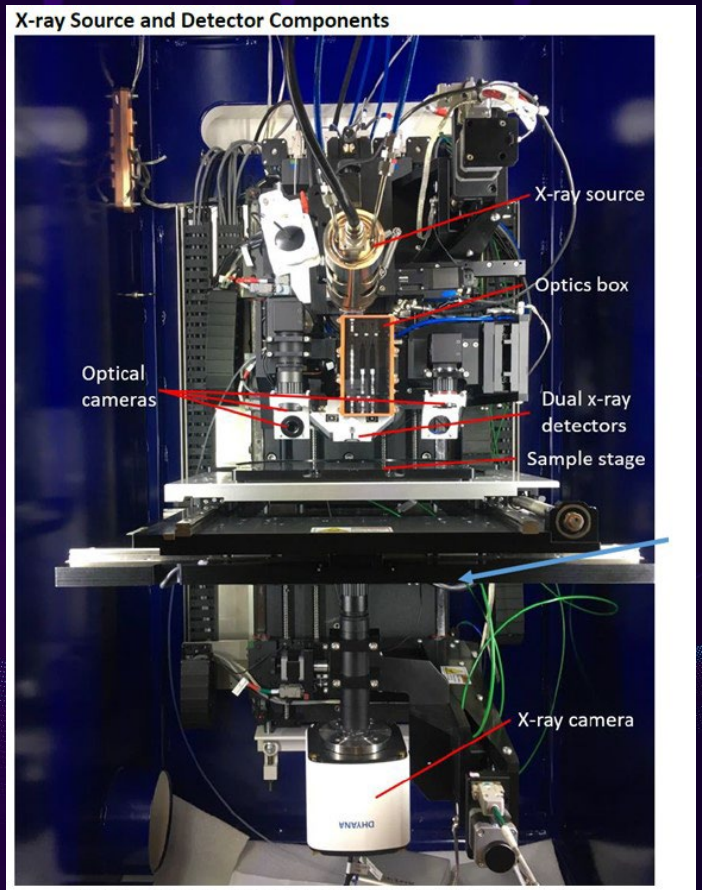
- Apply wafer dicing/coring tool

Listen



- Optical thermomechanical simultaneous inspection
- 10X speed up goal

Stimulate and Listen



System interior of AttoMap showing critical component locations
Sigray AttoMap Manual

- X-ray exposure to ID defects[1]
- Biased defect localization

[1]W. Lo et al. demonstrated a charging induced shift in transistor Vt on 5 nm FinFET devices at ISTFA 2022 https://doi.org/10.31399/asm.cp.istfa2022p0153

Summary

- 3D Microsystem realization needs FA tool capability R&D to address existing gaps
  - Leveraging existing tools is not enough
  - Part of IEEE and EDFAS future needs roadmaps
- Three ways to address the accessibility gaps are:
  - Take apart
  - Listen
  - Stimulate and listen
- Ongoing research uses all three approaches
- Maintaining defect integrity without adding ambiguity is an overarching desire

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THANK YOU