



3D integration for HPC & AI

Active interposer technologies for advanced chiplet-based systems: CMOS to photonic and quantum architectures

What it is

The chiplet-on-interposer concept involves integrating a multiplicity of chips on a common Silicon platform unlike the concept of large monolithic systems on chip (SoCs).

The active interposer extends this notion by adding smart functions at interposer level, in particular by integrating CMOS components. The interposer is more than a simple interconnection platform; it becomes the foundation for analog and low power digital and photonic functions and increased 3D communication, especially with network-on-chip architectures.

What it can do

High performance computing & artificial intelligence:

- Big Data
- Deep learning
- Cryptanalyze & Crypto money
- Physical simulation
- Climate model
- Astrophysics

Embedded computing:

- Edge AI
- Aeronautics
- Automotive
- Internet of Things

Work performed in the frame
of the IRT Nanoelec consortium



What makes it unique

Active interposer architecture offers multiple advantages:

Architecture agility through partitioning:

- Large single die divided in a multitude of smaller dies ensuring lower advanced node costs
- Highly configurable, optimized chiplets based on generic computing cores, GPU, FPGA fabric, AI accelerators, advanced memories, etc.
- Analog functions economically moved to interposer in a relaxed CMOS node; I/O services can be included

Performance breakthrough compatible with mass production:

- Power efficiency through embedded DC/DC converters
- 3D links for high performance with modern communication protocols and network-on-chip architectures
- Manufacturing and packaging demonstrated on 300 mm CMOS platform

Results

The INTACT proof of concept uses 96-core architecture comprising 6 chiplets (FDSOI 28 nm node) 3D-stacked on an active silicon interposer (CMOS 65 nm node).

- **Advanced 3D Technology:** 150,000 chiplet connections using ultra fine pitch die-to-die interconnect, 14,000 TSVs through interposer
- **Advanced 3D Architecture:** active interposer providing network-on-chip for chiplet-to-chiplet communication in a scalable, configurable, cache coherent system

CEA Leti's results pave the way to future high efficiency systems for high performance computing.

What's next

Pioneering mutation in advanced system integration:

- Active interposer to photonic interposer: Optical Network-on-Chip (ONoC), integrated wave guides and 3D technology
- 3D integration technological roadmap for density increase including High Density Through Silicon Vias TSV ($\varnothing 1 \mu\text{m}$ H10 μm) and hybrid bonding
- Superconducting integration for quantum and spatial cryogenic systems

CEA-Leti, technology research institute

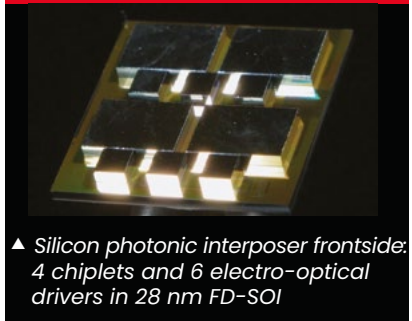
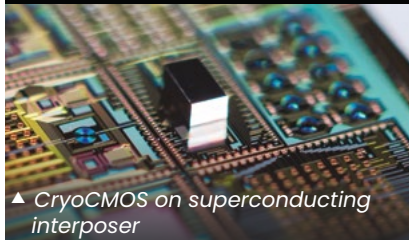
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Main Publications

- D. Saint-Patrice et al., "Process Integration of Photonic Interposer for Chiplet-based 3D Systems," ECTC 2023
- P. Coudrain, et al., "Active Interposer Technology for Chiplet-Based Advanced 3D System Architectures," ECTC 2019
- C. Thomas et al., "Superconducting routing platform for large-scale integration of quantum technologies," Mater. Quantum. Technol. 2022



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