

Article Overview

3D silicon photonics chips integrate optical and electronic components in three dimensions, enabling high-speed data transmission, compact 3D printing, and advanced co-packaged optics applications.

Overview

3D silicon photonics (SiPh) combines silicon-based photonic waveguides with electronic circuits to transmit and process optical signals on a chip. By leveraging mature CMOS fabrication techniques, SiPh allows for high-bandwidth, low-latency, and energy-efficient data communication, making it ideal for hyperscale data centers, AI computing, and optical interconnects . The technology supports wavelength-division multiplexing (WDM), enabling multiple optical channels on a single chip for scalable communication architectures.

Chip-Based 3D Printing

A recent breakthrough demonstrates the use of silicon photonics in 3D printing. Researchers at MIT and the University of Texas developed a millimeter-scale photonic chip that emits reconfigurable visible-light holograms into a resin, curing it into solid shapes without mechanical movement . This chip uses an array of optical antennas to steer light beams, enabling rapid formation of 2D and potentially 3D structures. The approach combines silicon photonics and photochemistry, offering a portable, handheld 3D printing solution that could revolutionize prototyping, medical device fabrication, and on-site manufacturing.

3D Integration and Co-Packaged Optics

Advanced packaging techniques, such as 3D chiplets hetero-integration and co-packaged optics (CPO), are critical for improving system performance in high-performance computing and AI applications . These methods integrate multiple silicon-based chips in three dimensions, addressing challenges like thermal dissipation, through-silicon via (TSV) reliability, and redistribution layer (RDL) integrity. Glass substrates and femtosecond laser processing are emerging as promising solutions for precise 3D integration, enhancing mechanical, thermal, and optical performance.

Applications

- o High-speed data communication: 3D SiPh chips enable energy-efficient optical transceivers, reducing power consumption in data centers while supporting multi-channel WDM systems .
- o Additive manufacturing: Chip-based 3D printers using SiPh can create complex structures rapidly, including medical components and engineering prototypes .
- o AI and HPC systems: 3D integration of photonic and electronic chips allows for compact, high-bandwidth interconnects between CPUs, GPUs, and memory modules .

Challenges and Future Directions

Key challenges include alignment precision, thermal management, and fabrication complexity. Future research focuses on scaling 3D photonic integration, improving optical antenna arrays, and developing fully integrated 3D holographic printing systems. The combination of silicon photonics, advanced packaging, and 3D integration is expected to drive next-generation computing, communication, and manufacturing technologies.

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The combining microelectronic devices and associated technologies onto a single silicon chip poses a substantial

This work combines the fields of silicon photonics and photochemistry to propose the first chip-based 3D-printing technology. The

This paper investigates the opportunity and challenges of 3D silicon photonic electronic integrated circuits (3D EPICs) scaling to

3D printing and silicon photonics have combined in a rather exciting way this week. Researchers at MIT have

The chip-based printer uses silicon photonics and advanced photochemistry for non-mechanical 3D printing with visible-light holograms.

First, we define the photonic actuator as the key primitive element shared among all processors, and next we outline

A compact, high-performance silicon photonics-based light detection and ranging system for three-dimensional

Photonic AI chips can process information at high speed, but current designs are constrained by planar layouts. Here,

3D photonic interconnect chips designed to accelerate AI training and inference with breakthrough

Here we present a solution to this long-standing overhead through dense three-dimensional

Researchers at MIT have engineered a novel 3D printing design on a single computer chip,

3D Silicon Photonics Chip Technology

Microelectromechanical systems (MEMS) technology can enhance silicon photonics with building blocks that are

Silicon photonic devices can be made using existing semiconductor fabrication techniques, and because

We propose and demonstrate the first chip-based 3D printer, consisting of a silicon-photonics chip that emits non-mechanically

What is Silicon Photonics (SiPh)? Silicon photonics (SiPh) is a technology that combines electronics and photonics,

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