

One Technology to Power Them All: Monolithic 3D for AI, Photonics, XR, and Sensing

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For more than half a century, semiconductor innovation has focused on making better individual devices. Today, however, the greatest challenge is no longer the device itself, but how diverse technologies are integrated to meet the demands of AI. What if the next semiconductor revolution is not another device, but an entirely new way of building chips? In this talk, I will present **Monolithic Three-Dimensional Integration (M3D)** as a universal semiconductor platform that directly integrates diverse single-crystal materials onto completed integrated circuits. By unifying low-temperature growth and semiconductor nanomembrane transfer into a single manufacturing strategy, M3D enables wafer-free heterogeneous integration with lithographic alignment and nanometer-scale vertical interconnects. Rather than requiring different integration technologies for logic, memory, photonics, displays, and sensing, M3D provides a common platform that brings them together on one chip [1-5].

I will first present how **growth-based M3D** establishes a monolithic platform for AI hardware through vertically integrated CMOS, logic-memory integration, capacitorless DRAM, and nanometer-pitch vertical interconnects [1,2]. By dramatically reducing data movement and enabling dense logic-memory integration, M3D attacks the memory wall at its architectural root. While M3D extends the scalability of the von Neumann architecture, I will also introduce CIREN, a fundamentally new inference architecture that eliminates the memory wall altogether. By encoding computation into deterministic device geometries instead of programmable analog states, CIREN finally delivers the long-promised vision of compute-in-memory—ultra-low-power, high-throughput AI inference without programming overhead, drift, or analog variability.

I will then present **transfer-based M3D** enabled by remote epitaxy and semiconductor nanomembranes, extending the M3D platform beyond electronics into optoelectronics and photonics [3,4]. This platform enables resonant-cavity microLEDs for ultrabright XR displays and energy-efficient optical interconnects, wafer-scale III-V lasers and electro-optic membranes for photonic integrated circuits, and ultrathin complex-oxide nanomembranes for room-temperature infrared imaging [6]. Together, these examples demonstrate how the M3D can simultaneously enable technologies that have traditionally evolved as independent fields.

From AI accelerators to XR displays, integrated photonics, and infrared imaging, these advances are all manifestations of the same manufacturing philosophy. **The next semiconductor revolution will not be defined by a better transistor. It will be defined by a universal platform that brings every technology together.** M3D represents a transition from application-specific innovation to a universal semiconductor platform capable of powering the next generation of AI, XR, photonics, and sensing.

References

[1] *Nature* Vol. 614, 88–94 (2023), [2] *Nature*, Vol. 636, 615-621 (2024), [3] *Nature*, Vol. 614, 81–87 (2023), [4] *Nature*, Vol. 641, 98-105 (2025), [5] *Science*, Vol. 377, 859-864 (2022). [6] *Nature*, Vol. 641, 98-105 (2025)



Biography

Jeehwan Kim is a tenured associate professor at MIT whose research advances materials, devices, and three-dimensional integration for the next generation of computing and electronics. His group develops new ways to grow and integrate high-quality materials for advanced chips, photonics, and displays.

Before joining MIT in 2015, Kim worked on next-generation CMOS and energy devices at IBM T. J. Watson Research Center, where he was named a Master Inventor. His honors include the 2024 Falling Walls Science Breakthrough of the Year in Engineering and Technology, the DARPA Young Faculty Award and Director's Fellowship, and recognition as a Samsung Fellow. He serves as an Associate Editor of *Science Advances* and Director of the MIT Display Center.

Kim received his B.S. from Hongik University, M.S. from Seoul National University, and Ph.D. from UCLA, all in materials science.