Metaphotonics for High-Performance Optical Interconnects

Jaehyuck Jang*
Samsung Advanced Institute of Technology (SAIT), Samsung-ro 130, Suwon, Korea
**E-mail: jae0111.jang@samsung.com*

Optical interconnects—communication systems that transmit signals using light—have attracted significant attention, as emphasized in NVIDIA's GTC 2025 keynote, which showcased their integrated silicon photonic platform, i.e. Spectrum-X and quantum-X for high-speed optical switching [1]. With increasing competition among major players in the optical interconnect field, the development of diverse, high-performance optical components within photonic integrated circuits (PICs) has become crucial [2]. Modern PICs integrate a growing number of photonic elements—such as waveguides, I/O couplers, directional couplers, modulators, detectors, and light sources—on a single chip to enable complex functions like wavelength routing, switching, and signal processing. In this rapidly evolving landscape, metaphotonics presents a promising niche by enabling unprecedented optical functionalities in conventional optical components.

One notable example is the flat metasurface lens [3], which can focus or collimate light using subwavelength nanostructures within a thickness of only a few wavelengths. Compared to conventional microlenses used in semiconductor packaging, flat lenses offer easier fabrication and superior chromatic aberration correction, all within a compact form factor. In this presentation, I will introduce an achromatic vertical coupler based on metaphotonics that collimates light from a wavelength- and temperature-dispersive apodized grating coupler and directs it toward an optical fiber package. Additionally, I will highlight other metaphotonic components that can be integrated into co-packaged optics, illustrating their potential to enhance performance, reduce footprint, and simplify packaging in next-generation optical interconnects.

References

1. NVIDIA. *NVIDIA Spectrum-X*. https://www.nvidia.com/en-us/networking/spectrumx/ (accessed 15 Apr. 2025).
2. Three-dimensional photonic integration for ultra-low-energy, high-bandwidth interchip data links, *Nat. Photonics* (2025).
3. An achromatic metafiber for focusing and imaging across the entire telecommunication range, *Nat. Commun.* **13**, 4183 (2022).