How Can Photonics Enable the Bandwidth Densities with Lower Energy per Bit in Emerging SIP?

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During the 73rd ECTC event, the President's panel directed its attention towards a pivotal inquiry: "How can Photonics Enable Bandwidth Densities with Lower Energy per Bit in Emerging SIP?" The panel engaged in an extensive discussion, delving into the tools, technologies, and notably, photonics-based approaches that hold the potential to elevate the industry's interconnection bandwidth density in System-in-Package (SiP) configurations. Within this discourse, the panel addressed some of the most formidable impediments to widespread adoption, including the challenge of achieving energy-efficient performance per bit that aligns with the industry's roadmaps and established standards for both package-level and on-chip interconnection protocols.

The panelists commenced their discussion with a compelling array of motivations, rooted in the following pivotal facts: The escalating power consumption of semiconductor chips, a stark illustration of Dennard scaling's demise. The widespread adoption of water-cooling solutions and the imminent emergence of immersion cooling technologies. Projections indicating that Artificial Intelligence (AI) will account for a staggering 80% of data center power consumption by 2040, even though the overall data center power usage growth rate is substantially lower than the rapid deployment of AI hardware. Furthermore, the exponential growth in the size of AI models, expected to reach a 1000-fold increase by 2030, with deployed AI models doubling in size annually, a rate six times faster than that of research models. Additionally, the diminishing pace of transistor performance improvements and the constrictions imposed by thermal limitations at the package level. Finally, the soaring costs associated with chip design, marked by exponential growth in development expenditures for creating next-generation processors.

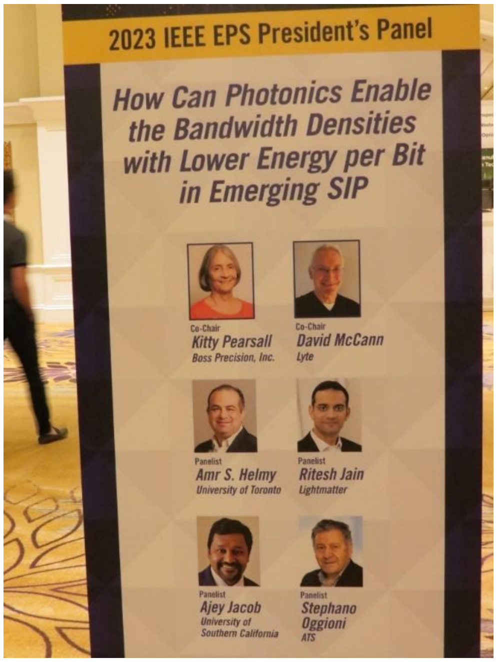
Fueled by these compelling motivations, the panel converged on heterogenous integration, coupled with advanced packaging, as a viable and strategic pathway forward to address the multifaceted challenges and objectives at hand.

Heterogeneous integration and advanced packaging technologies constitute a foundational platform for the integration of photonics, offering a fertile ground for innovation across various domains. These domains encompass, among others:

- Power delivery, capable of meeting the scalability demands of system expansion.
- Thermal management at the package and system levels, designed to withstand the workloads in future larger workload constructs.
- Fiber attachment processes aimed at enhancing throughput, thus capturing the capacity needs of future systems.
- Promotion of ecosystem standardization and consolidation of the supply chain.

Each of these advantages plays a pivotal and indispensable role in ushering in a new era and providing a pathway to enable photonics, thereby achieving higher bandwidth densities with lower energy per bit in emerging System-in-Package (SIP) configurations.

However, realizing the full potential of these technologies and implementations envisioned in this pursuit necessitates extended collaboration across various sectors, including System Architecture & Packaging Design, Miniaturization, Modularization, Hybrid Component Integration, Power Delivery, and Thermal Management. The active participation of industry partners remains paramount in achieving the earliest implementation. Such contributions must span the entire supply chain, encompassing Optical Devices, Materials, Design Methodologies, Simulation Software, Substrate Construction, and Test Methods. True supply chain readiness can only be realized through collaborative efforts in the initial phases of projects. The ultimate goal is to ensure that these collaborative efforts yield outcomes that seamlessly integrate into systems while maintaining peak performance.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