Optical Interconnects and Packaging

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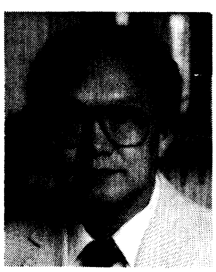
As electronic circuits in chips become more dense, they will need more input/output pins. As electronic systems become more powerful, they will require more chips. To communicate among one another, interchip interconnections of higher bandwidths will be required. Similarly increasing communication requirements with time exist among electronic systems, for example, among supercomputers in the United States and among workstations across the country.

To satisfy many of these long-distance communication needs, optical fibers networks have already proven useful. Connecting computers via optical fiber with a fiber distributed data interface standard provides a tenfold improvement over Ethernet speeds. But how far will optics penetrate into electronic systems by filling the needs of electronics? Should fibers or free-space optical interconnects be used for optical interconnections among boards? Should free-space or optical waveguides be used for optical interconnections among multichip modules (MCMs) in boards and among chips in MCMs? In other words, which optical interconnection technology in the electronic packaging hierarchy can be applied beneficially? What are the potentials and limitations of different optical interconnection technologies? What architectures and which optical interconnection technology can provide better performances than electrical interconnects? What is the status of the enabling technologies that support different optical interconnect approaches?

To find answers to some of these questions related to free-space optical interconnects, Cloonan reports in this special section on the results of a comparative study of optical and electronic interconnects for large asynchronous transfer mode packet switching applications. Tsang and Goblick investigate the application of free-space optical links for interprocessor communication in multiprocessor parallel computers. Free-space transmitter and receiver modules have been fabricated and installed in a card cage enclosure to provide full connectivity among a set of processors connected to the ring nodes of a time-division multiplexed ring network. Li, Wang, and Sharony explore connectivity-enhanced mesh-based networks by utilizing the unique advantages of free-space optics, which include large power fan-out per node capability and the ability for spatial-angular multiplexing. To implement many of these optical interconnection systems, polarizing beamsplitter cubes and micro-optics are frequently used. Pezzaniti and Chipman examine the polarization aberration resulting from cascading polarizing beamsplitter cubes and describe how to minimize beam-routing errors. Sauer et al. discuss the advantages of combining diffractive and refractive optics and demonstrate their applications in a 2-D perfect shuffle interconnection network architecture. They also discuss the importance of mechanical alignment and wavelength tolerances of the interconnection system. Patra et al. analyze quantitatively the impact of assembly tolerance and the working environment (e.g., operating temperature) on the alignability of an optoelectronic package, with the objectives of determining the important specifications of critical components and the assembly technologies. This quantitative analysis is also intended for incorporation later into a computer-aided design system for carrying out signal integrity analysis on optical interconnection links. Fan et al. present the architecture of an integrated computer-aided design system to be developed for designing optoelectronic packages.

For optical interconnects with optical waveguides, Tang, Chen, and Peskin examine the maximum packing density and interconnection length limits of a highly parallel, polymer-based single-mode bus array to be used for inter-MCM interconnects. Koh, Carter, and Boyd present an optical interconnection network design for synchronous global clock distribution on MCMs using a hybrid (silicon oxynitride/silica glass) H-tree waveguide structure and then analyze its performance. Önal, Altintas, and Ozaktas develop computer-aided analysis and simulation tools for complex passive integrated optical circuits of arbitrary rectilinear topology so that the minimum spacings between the waveguides that result in acceptable crosstalk and noise levels can be determined.

The results reported in the ten papers in this special issue represent significant progress in the field. However, there is still a large amount of basic, applied, developmental, and manufacturable research required before these optical and optoelectronic technologies can emerge as accepted technologies. As guest editor I hope that this special section will be helpful toward future development of optical interconnects and packaging. I sincerely thank the editor of *Optical Engineering* for agreeing to have the special section and the reviewers of the manuscripts for contributing their valuable time and effort.



Sing H. Lee received his PhD from the University of California, Berkeley, in 1968. He has been a professor of electrical and computer engineering at the University of California, San Diego, since 1979. His research interests include optoelectronic packaging technology, optical interconnects, smart spatial light modulator fabrication and testing, and computer-generated hologram fabrication and replication. Professor Lee has published more than 115 refereed journal publications in the area of devices and systems for optical information processing. He has been a fellow of the Optical Society of America since 1983, and a fellow of SPIE since 1990.