Guest Editorial
Special Issue on Optical Interconnects

AS GUEST EDITORS, we are pleased to introduce the JOURNAL OF LIGHTWAVE TECHNOLOGY (JLT) Special Issue on Optical Interconnects. This issue was compiled in order to document the current status of, as well as highlight some of the outstanding progress that has been made in, the field of optical interconnects since the JLT special issues of the 1990s, when the topic was in its infancy. Due to the increase in individual line rates (10 Gb/s and higher), the increase in the aggregate data rate for systems (> terabits per second), and the corresponding need to increase the bandwidth density in these systems, optical interconnects are beginning to replace conventional electrical interconnects. The main advantages of optical interconnects include the following:

1) longer link lengths for the same data rate;
2) increased bandwidth density;
3) smaller cables and connectors;
4) less susceptibility to electromagnetic interference (EMI);
5) potentially lower power dissipation.

The term *optical interconnect* is commonly used to refer to short-reach (< 600 m) optical links with many parallel optical channels (typically tens of channels per interconnect). These optical interconnects are used to make connections from chip to chip inside of a system where the chips may be, for example, processors, memory chips, input/output (I/O) chips, or cross-connect switches. Typical distances from chip to chip are < 0.5 m for connections on the same board, < 2 m for connections from one board to another, < 4 m for connections from one shelf to another, or < 100 m for connections from cabinet to cabinet in the same data center. Due to the short distances, multimode optical fiber or optical waveguides are commonly used.

Optical interconnects are commercially available today in module form for link lengths up to 600 m and data rates per channel of 2.5 Gb/s. These modules mount directly to a printed circuit board to make electrical connection to the integrated circuits and use multimode optical ribbon fiber to make optical connection from a transmitter module to a receiver module. As mentioned previously, due to the need for increased individual line rates, increased aggregate data rates, and increased bandwidth density, there is a need to move optical interconnects closer to the I/O pin electronics. This requires several advances in the following areas:

- optoelectronic devices;
- optical packaging;
- electrical packaging;
- thermal management;
- waveguide technology.

In order for optical interconnects to become more pervasive in these systems, this new technology must be low cost and competitive with the cost of conventional electrical interconnects.

This Special Issue of JLT covers devices, integrated circuits, subassemblies, modules, architectures, and systems related to short distance "chip-to-chip," "in-the-box," and "box-to-box" data communications applications that use free-space or guided-wave optical interconnection media. Specific areas covered include the following:

- device integration;
- planar embedded waveguides;
- flexible waveguides;
- three-dimensional free-space interconnections;
- optical-switch-based reconfigurable optical interconnection concepts;
- hybrid integration;
- low-cost packaging technologies;
- vertical-cavity surface-emitting laser-based system experiments.

For this Special Issue, we received 27 manuscripts for consideration from at least six different countries. Included within this total were two invited papers selected to cover two major applications of optical interconnects. With the assistance of an international team of expert reviewers, we have selected 20 papers for publication in this issue. During the paper selection process, we ensured that, for any paper in which one of the Guest Editors had involvement, responsibility for its handling was allocated entirely to one of the other Guest Editors.

We hope that this Special Issue of JLT will provide a useful cross section of the state-of-the-art in optical interconnects. The next several years are sure to be an exciting and fast-growing time in the field of optical interconnects. We are confident that there will be future Special Issues on optical interconnects.

In conclusion, we would like to thank Alan Willner, Editor-in-Chief of the JOURNAL OF LIGHTWAVE TECHNOLOGY,

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for offering us the opportunity to produce this Special Issue. We would also like to thank Douglas Hargis, Publications Coordinator, for his enthusiasm, efficiency, and unfailing helpfulness in its preparation. We are also very grateful to the large team of expert reviewers who undertook the detailed technical review of the manuscripts in a time frame consistent with the schedule for this Special Issue. Finally, we would like to thank all of the authors for their support and for their cooperation in meeting the deadlines so as to permit this Special Issue to meet its scheduled publication date.

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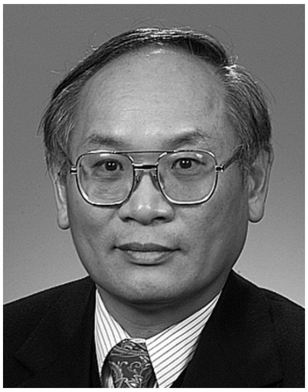
She joined Hewlett-Packard Laboratories (now Agilent), Palo Alto, CA, in November 1996. Since January 2002, she has been Project Manager with the primary research responsibility of next-generation parallel optics. She is the author of approximately 30 technical publications.

Dr. Buckman Windover was an active participant and voting member in the 10-Gigabit Ethernet Committee. From 2000 to 2003, she served on the Optical Components: Interconnect and Processing Subcommittee of the Conference on Lasers and Electro-Optics (CLEO).

Karl J. Ebeling (SM'83) was born in Hehlen, Germany, on October 27, 1949. He received the Diplom-Physiker degree and the Dr.rer.nat. and Dr.rer.nat.habil. degrees, both in physics, from the University of Göttingen, Germany, in 1973, 1976, and 1984, respectively.

In 1982 and 1983, he was a Guest Scientist at AT&T Bell Laboratories, Holmdel, NJ. In 1985, he was appointed Professor of electrical engineering at the Technical University of Braunschweig, Braunschweig, Germany. He has been a Professor at the University of Ulm, Ulm, Germany, Head of the Optoelectronics Department since 1989, and a Director of the Microtechnology Center since 1993. From 1993 to 1995, he served as the Dean of the Faculty of Electrical Engineering and from 1995 to 2001, he was a Vice President of the University of Ulm, responsible for research matters, among others. While on leave from the University from 2001 to 2003, he was Senior Vice President of Central Research at Infineon Technologies, Munich, Germany, the former semiconductor branch of Siemens Corporation. In fall 2003, he returned to the University of Ulm as Rektor. He has published more than 300 technical papers and a book titled *Integrated Optoelectronics* (Berlin, Germany: Springer-Verlag. His research interests include high-bit-rate optical communication systems and novel semiconductor lasers, in particular vertical-cavity surface-emitting laser diodes and short wavelength emitters based on nitrides.

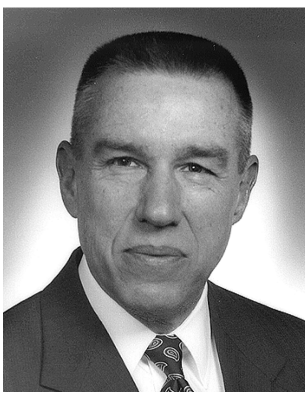
Prof. Eberling was elected as a Member of the Heidelberg Academy of Science in 1998. He received the Gottfried Wilhelm Leibniz Award of the Deutsche Forschungsgemeinschaft in 1987, the Book Award of the Informationtechnische Gesellschaft in 1990, the Karl Heinz Beckurts Award in 1997, the Photonics West Optoelectronics Paper Award in 2000, and the MOC'01 Award in 2001.



John N. Lee (M'83–SM'85) received the B.S. degree in physics from Union College, Schenectady, NY, in 1966 and the M.S. and Ph.D. degrees in physics from Johns Hopkins University, Baltimore, MD, in 1968 and 1971, respectively.

He was formerly with the Harry Diamond Laboratories from 1971 to 1980. He joined the U.S. Naval Research Laboratory, Washington, DC, in 1980, where he is currently a Senior Staff Member of the Applied Optics Branch of the Optical Sciences Division. His research and development activities have included acoustooptic devices, systems and techniques, optical processing architectures, spatial light modulators and materials, radiation effects on optics, and development of reconnaissance and surveillance systems with advanced optical and hyperspectral sensors. He has authored or coauthored numerous papers and several book chapters and edited books on acoustooptic signal processing and optical processor design.

Dr. Lee is a Member of Optical Society of America (OSA).



James Meindl (M'56–SM'66–F'68–LF'97) received the Bachelor's, Master's, and Ph.D. degrees in electrical engineering from the Carnegie Institute of Technology (Carnegie Mellon University), Pittsburgh, PA.

He is the Director of the Joseph M. Pettit Microelectronics Research Center and the Joseph M. Pettit Chair Professor of Microelectronics at the Georgia Institute of Technology, Atlanta. He is also Director of the Interconnect Focus Center, a multi-university research effort managed jointly by the Microelectronics Advanced Research Corporation and the Department of Defense (DoD) Defense Advanced Research Projects Agency (DARPA). His current research interests focus on physical limits on gigascale integration and nanotechnology.

Dr. Meindl is a Life Fellow of the American Association for the Advancement of Science and a Member of the American Academy of Arts and Sciences and the National Academy of Engineering. Recently, he was awarded first place on the IEEE International Solid State Circuits Conference 50-Year Anniversary Author Honor Roll. He received the Hamerschlag Distinguished Alumnus Award from Carnegie Mellon University in 1997, the SIA University Research Award in 1999, the IEEE Third Millenium Medal in 2000, and the Georgia Institute of Technology Class of 1934 Distinguished Professor Award in 2001. In September 2004, he will be presented with the 2004 SRC Aristotle Award, recognizing outstanding teaching in its broadest sense.

David A. B. Miller (M'84–SM'89–F'95) received the B.Sc. degree from St. Andrews University, St. Andrews, U.K., and the Ph.D. degree from Heriot-Watt University, Edinburgh, U.K., in 1979.

He was with Bell Laboratories from 1981 to 1996 and, from 1987 to 1996, he was head of the department that later became known as the Advanced Photonics Research Department. He is currently the W. M. Keck Professor of Electrical Engineering at Stanford University, Stanford, CA, and the Director of its Ginzton Laboratory and the Solid State and Photonics Laboratory. His research interests include quantum-well optoelectronic physics and devices and fundamentals and applications of optics in information, sensing, switching, and processing. He has published more than 200 scientific papers and holds more than 40 patents.

Dr. Miller has served as a Board Member for both the Optical Society of America (OSA) and IEEE Lasers & Electro-Optics Society (LEOS) and in various other society and conference committees. He was President of the IEEE LEOS in 1995. He was awarded the Adolph Lomb Medal and the R. W. Wood Prize from OSA, the International Prize in Optics from the International Commission for Optics, and the IEEE Third Millennium Medal. He also holds honorary degrees from the Vrije Universiteit Brussel, Brussels, Belgium, and from the Heriot-Watt University. He is a Fellow of the Royal Societies of London and Edinburgh, OSA, and the American Physical Society (APS).