Introduction to the issue on integrated optics

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THIS issue of the IEEE JOURNAL OF SELECTED TOPICS IN QUANTUM ELECTRONICS is devoted to providing an overview of recent progress in the fields of guided-wave optics, photonic integrated devices, and optoelectronic integrated circuits. Published jointly with the JOURNAL OF LIGHTWAVE TECHNOLOGY, it is intended to summarize and highlight new developments in integrated-optical components and related technologies. The topics covered in this issue include passive as well as active optical waveguide devices in dielectric and semiconductor materials, with the exception of discrete semiconductor lasers and laser arrays, which will be highlighted in another issue of JSTQE.

One of the most exciting developments that have occurred in recent years is the first commercial application of integrated-optical devices in analog and digital fiber-optic communication systems. High-speed electrooptic intensity modulators on lithium niobate and monolithically integrated electroabsorption modulators on indium phosphide, for example, are widely used in long-distance terrestrial and submarine lightwave systems to encode the digital signals with little or no additional frequency-chirp into the optical carriers. Moreover, fast electrooptic polarization scramblers have become an important component in ultra-long transoceanic communication systems to eliminate anisotropic gain saturation in the optical amplifiers. In addition, integrated-optical wavelength multiplexers and demultiplexers on silica are employed in the first multi-wavelength communication systems to combine and separate the various optical carriers at the transmitters and receivers. It is expected that these applications are just the beginning of an even more widespread commercial use of integrated-optical devices in future long-distance and local-area lightwave networks.

This important new development in Integrated Optics is reflected in many of the papers contributed to this issue. In an invited paper, Smit and van Dam of Delft University of Technology review the state-of-the-art of phased-array based wavelength multiplexers and multifrequency lasers for applications in multiwavelength communication systems and future all-optical networks. Moreover, Wehrmann *et al.* of the University of Paderborn report on a fully packaged, reconfigurable 2×2 wavelength add–drop multiplexer, which is based on a tunable acoustooptic mode converter in lithium niobate. Veselka and Korotky of Lucent Technologies demonstrate new methods for generating short optical pulses in advanced soliton transmission systems by using high-speed lithium niobate modulators. Takiguchi *et al.* of NTT present a photonic integrated waveguide circuit on silica that can serve as a programmable group-delay equalizer in fiberoptic transmission systems. And an invited paper by Renaud *et al.* of Alcatel Alsthom Recherche describes compact implementations of fast guided-wave switch arrays on indium phosphide and discusses potential applications in optical transport and switching networks.

While the performance and functionality of integrated-optical components is continuously improving, they face strong competition from alternative solutions based on, e.g., fiber-optic or microoptic devices. A joint invited paper by researchers from Philips Optoelectronics Centre, the Technical University of Eindhoven, and Delft University of Technology (Pennings *et al.*) critically assesses the merits and prospects of integrated-optical devices in two specific applications. By comparing the time scale of the development of integrated-optical components to that of integrated electrical circuits, they conclude that earlier expectations of Integrated Optics were ill-based and, although developments in the field of wavelength multiplexing are promising, that a major breakthrough is not to be expected before the turn of the century.

However, significant progress has been made in the monolithic integration of semiconductor lasers with high-speed modulators as well as in integrating high-speed photodetectors with front-end receiver electronics, leading to a substantial reduction in device sizes and costs. An invited paper by Ramdane *et al.* of FRANCE TELECOM/CNET reviews various solutions for monolithic integration of multiple-quantum-well distributed-feedback lasers with high-speed electroabsorption modulators on indium phosphide. Another approach for integrating active and passive optical components is described in an invited paper by Baumann *et al.* of the University of Paderborn, who have successfully demonstrated erbium-doped optical amplifiers and tunable lasers in lithium niobate waveguides. They report the first monolithic integration of a lithium niobate DBR laser with a high-speed electrooptic intensity modulator. Finally, Bach *et al.* of Heinrich–Hertz Institut discuss the design and performance of a monolithically integrated optical receiver on indium phosphide, which combines a high-speed waveguide photodiode with a traveling-wave electrical amplifier.

We hope that this issue will be useful in disseminating some of the recent progress being made in the field of Integrated Optics and that it will stimulate new ideas for further advances in the performance, technology, and application of integrated-optical devices and circuits. We would like to thank the authors and reviewers for their invaluable contributions and we are especially grateful to Dr. M. Kawachi of NTT Optoelectronics Laboratories who initially served as one of the Guest Editors for this issue.

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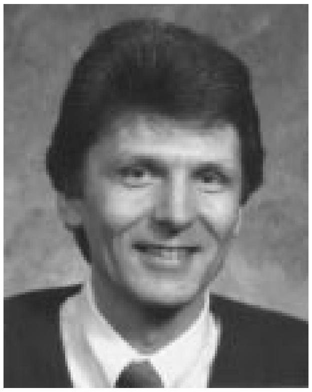
FRED HEISMANN, *Guest Editor*
Bell Laboratories
Lucent Technologies
Holmdel, NJ 07733-3030 USA

KATSUNARI OKAMOTO, *Guest Editor*
NTT Optoelectronics Laboratories
Tokai 162, Naka-Gun
Ibaraki Pref., Japan

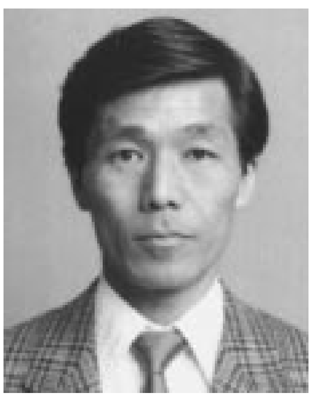
MEINT K. SMIT, *Guest Editor*
Delft University of Technology
Faculty of Electrical Engineering
2628 CD Delft, The Netherlands



Fred Heismann received the Diplom-Physiker degree (M.S. degree in physics) from the University of Bielefeld, Germany, in 1980 and the Doktor-Ingenieur (Ph.D.) degree in electrical engineering from the Technical University Hamburg-Harburg, Germany, in 1986, where he demonstrated a novel scheme for tunable electrooptic frequency shifting in single-mode waveguides.

He joined Bell Laboratories in 1985 and has since been engaged in research on electrooptic waveguide components and their applications in high-capacity lightwave communication systems. His work has centered on narrow-band tunable wavelength filters and fast polarization modulators in lithium niobate and III–V semiconductor materials. He has pioneered fast automatic polarization controllers with inherently unlimited transformation range which are capable of stabilizing rapid polarization fluctuations in single-mode optical fibers. With these controllers he has demonstrated fully automatic polarization demultiplexing in NRZ and soliton transmission systems. Recently, he has developed various high-speed polarization scramblers for optically-amplified transoceanic communication systems.

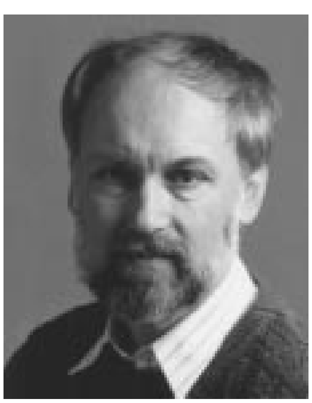
Dr. Heismann is a member of the American Physical Society, the Optical Society of America, and the IEEE/LEOS.



Katsunari Okamoto (M'85) was born in Hiroshima, Japan, on October 19, 1949. He received the B.S., M.S., and Ph.D. degrees in electronics engineering from Tokyo University, Tokyo, Japan, in 1972, 1974, and 1977, respectively.

He joined Ibaraki Electrical Communication Laboratory, Nippon Telegraph and Telephone Corporation, Ibaraki, Japan, in 1977, and has been engaged in research on transmission characteristics of multimode, dispersion-flattened single-mode, single-polarization (PANDA) fibers, and fiber-optic components. From September 1982 to September 1983, he joined the Optical Fiber Group, Southampton University, Southampton, England, where he was engaged in research on birefringent optical fibers. From October 1987 to October 1988, he stayed at RCAST (Research Center for Advanced Science & Technology) of Tokyo University as an Associate Professor. Since February 1990, he has been working on computer-aided-design (CAD) and fabrication of silica-based planar waveguide devices at Ibaraki R&D Center, NTT Opto-electronics Laboratories. He is presently a senior research engineer and supervisor of the photonic component laboratory.

Dr. Okamoto is a member of the Institute of Electronics, Information, and Communication Engineers of Japan and the Japan Society of Applied Physics.



Meint K. Smit (A'93) was born in Vlissingen, The Netherlands, in 1951. He received the M.S. degree (with honors) and Ph.D. degree (with honors) in electrical engineering from the Delft University of Technology.

He started in 1974 as a Research Scientist with the NIWARS (Netherlands Interdepartmental Working Group on Application of Remote Sensing Technology), then in 1976, he also was with the Delft University of Technology as an Assistant Professor with responsibility for research in microwave remote sensing and FM-CW radar development. He switched to optical communication in 1981 and has set up facilities for fabrication of silicon-based integrated optical devices. He invented the phased-array wavelength demultiplexer, which is presently being widely applied. He worked on the design of multimode interference couplers, optical switches, measurement, and characterization of electrooptical devices, and development of computer-aided design tools. From 1991 to 1992, he was on leave at the Institute of Quantum Electronics, ETH Zürich, where he worked on development of a fast and compact polarization independent optical switch.