Photonic Materials

Alastair M. Glass, Guest Editor

Optical technologies have advanced dramatically in recent years. In just two decades the transparency of optical fibers has improved by four orders of magnitude. Semiconductor lasers have evolved from a new invention to highly reliable, high performance commercial devices for wide bandwidth optical communications. New approaches to higher frequency modulation, wider bandwidth transmission, more sensitive detection and optical amplification are constantly being developed. Fundamental limitations are sufficiently far removed from current capabilities that considerable further progress can be anticipated. These advances have provided the stimulus for a much broader investigation of the potential of optics in future information technologies in which optics and electronics play complementary roles. This rapidly developing field is referred to as "photonics." Increasing attention is now being paid to applying optics to wide bandwidth switching systems and to exploring the potential of optics for image processing and computation.

Past progress in optical communication can be traced largely to the dramatic progress in optical fiber and compound semiconductor materials technologies. Likewise, future opportunities in photonic switching and information processing will depend critically on the development of improved photonic materials. The future role of optics in these conventionally electronic technologies, and the extent of that role, depends on whether materials can be designed and fabricated with the required characteristics.

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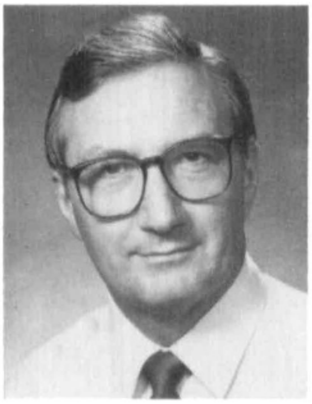
The articles in this issue will focus on some of the recent advances and current limitations of photonic materials for these emerging applications. My article, "Materials for Photonic Switching and Information Processing," will introduce the various materials systems being actively investigated for photonic switching and information processing, together with the relative merits and tradeoffs of each approach for future devices.

R.A. Becker reviews the materials, device designs, and range of applications of "Optical-Guided-Wave Modulators." The devices have become commercially available during the past three years, and products range from simple phase modulators to 8×8 switching matrices.

G.A. Meredith considers "Organic Materials for Nonlinear Optics," presenting an overview of the basis for and the many directions of invention and research.

D.Z. Anderson not only conveys enthusiasm for a "fledgling optical technology" in "Materials Demands for Optical Neural Networks" but also describes recent research, explains the general principles of neural network models, and isolates some of the pivotal materials issues.

A.R. Tanguay, Jr. thoroughly examines the fundamental "Physical and Technological Limitations of Optical Information Processing and Computing." He discusses the nature of computation from the perspective of identifying technology-independent limits and provides an example of a technology-dependent limit in the context of photorefractive volume holographic optical interconnections. ☐



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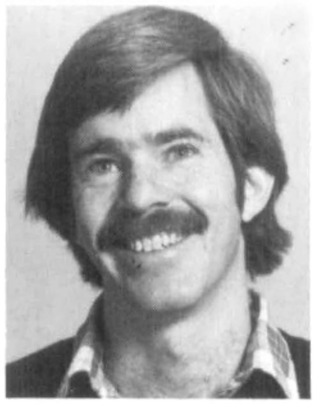

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Alastair M. Glass, Guest Editor for this issue of the MRS BULLETIN, is head of the Optical Materials Research Department of AT&T Bell Laboratories, Murray Hill, New Jersey. He received a PhD in physics from the University of British Columbia, Canada and a BSc from the University of London, England. Since joining Bell Laboratories, Glass has been involved with a wide variety of studies of optical and electrical effects in semiconductors, ferroelectrics, and dielectric materials. He was recently elected to the National Academy of Engineering and is chair of the National Materials Advisory Board Committee on Process Challenges in Compound Semiconductors.

Dana Z. Anderson received a BSEE from Cornell University and PhD in physics from the University of Arizona. From 1981 to 1984 he worked on gravitational wave optical interferometry at the California Institute of Technology. In 1984 he joined the faculty at the University of Colorado, where he is presently an assistant professor of physics and Fellow of the Joint Institute for Laboratory Astrophysics. Anderson is actively engaged in research in optical neural networks, nonlinear optics, and ring laser gyroscopes. In collaboration with the University's Optoelectronic Computing Systems Center, he is working to develop optical systems for associative memory, learned pattern mapping, and robotic sensing.

Richard A. Becker, currently a consultant, was most recently the manager of integrated optics components at Crystal Technology, Inc., Palo Alto, California, where he concentrated on advancing the development of commercially available optical-guided-wave devices. He was previously a member of the technical staff at Lincoln Laboratory, Massachusetts Institute of Technology, first with the Analog Device Technology Group and then with the Applied Physics Group. His research there focused on surface-acoustic-wave devices and $LiNbO_3$-based integrated-optic devices and systems, respectively.

Gerald R. Meredith, research supervisor of the Central Research and Development Department, E.I. du Pont de Nemours & Co., Wilmington, Delaware, joined Du Pont four years ago to lead a new effort in nonlinear optics, particularly organics. He was previously a member of the research staff at Xerox's Webster Research Center for five years. His research interests include optical processes in condensed-phase materials, including molecular mechanisms and experimental design. Meredith is a member of the Materials Research Society.

Armand R. Tanguay, Jr. is associate professor of electrical engineering and materials science at the University of Southern California. A recipient of the Rudolph Kingslake Medal of the Society for Photo-Optical Instrumentation Engineers in 1986, Tanguay is a Fellow of the Optical Society of America and a member of the Materials Research Society. His research interests include the crystal growth and characterization of electro-optic materials, dielectric thin film deposition and characterization, spatial light modulators, photorefractive volume holographic optical elements, integrated optical processing components, and the fundamental physical limitations of optical information processing and computing. □