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Optical computing: introduction by the feature editors

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This feature of *Applied Optics: Information Processing* on optical computing comprises thirty papers. Most of the papers evolved from papers presented at the Fifth Topical Meeting on Optical Computing held in March 1993 in Palm Springs, California.

This feature of *Applied Optics* represents the fifth in a series of features on optical computing. Most of the papers that follow are full treatments of the conference papers presented at the Optical Society of America's Fifth Biannual Topical Meeting on Optical Computing held 15–17 March 1993 in Palm Springs, Calif.[1] The four earlier feature issues on optical computing (15 May and 15 July, 1986, 1 May 1988, 10 May 1990, and 10 September 1992) were also associated with the topical meetings on optical computing that were held in March of 1985,[2] 1987,[3] 1989,[4] and 1991.[5] These topical meetings have been complemented on even-numbered years by a series of Optical Computing Conferences sponsored by the International Commission on Optics and held outside North America. These conferences were held in Toulon, France, in 1988, in Kobe, Japan, in 1990, and in Minsk, Byelorus, in 1992. The 1994 Optical Computing Conference will be held in Edinburgh, Scotland, in August 1994.

In the introduction to the 1992 feature, Jenkins *et al.*[6] attempted to predict the directions in which the field of optical computing would be likely to expand. They identified optical interconnection as the most promising opportunity for bringing optics into computing. This direction in technology permits the strength of the advanced electronic technology to be complemented with both the large temporal and spatial bandwidths available in the optical domain. This paradigm centers the active processing in electronics while relying on optical interconnection as the means of communication among the electronic printed circuit boards, multichip modules (MCM's), and integrated circuits of the system. This optical interconnection requires the integration and packaging of active integrated optoelectronic devices with passive optical interconnects such as diffractive optics, computer-generated holograms, and optically written holograms.

In addition, Jenkins *et al.* suggested that practical issues (weight, size, manufacturability, and stability) will start to become important for near-term applications. Whereas laboratory-achieved figures of merit (speed, parallelism, and capacity) would increase, extrapolations to what would ultimately be realizable and manufacturable would decrease to more realistic levels. Competition between electronic and optical technologies would then die out as the focus would be on complementing electronics rather than on competing with it. With that change in perception, attention would then be focused on the interface between conventional electronic and novel optical approaches.

In the short time since these predictions, it is clear that all the sentiments expressed were largely correct. It is clear that the role of optics in both computing and switching is to assist in the communication of information between higher-performance electronics. Thus the early 1980's idea of there being a role for an all-optical computer has been largely abandoned.

The beginning years of optical computing were also consumed with the belief that devices based on nonlinear optical effects could be the foundation for building large high-performance photonic systems. With this vision, primitive digital optical computing demonstrations were made with such devices. Within the past few years there has been the realiza-

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tion that optically interconnected electronics rather than optical logic offers more promise. Optical bistable devices, which on a single-pixel site perform fan-in, detection, programmable thresholding, memory, and modulation, are now being replaced by smart pixels in which all these tasks are separated and performed optimally, resulting in devices with high sensitivity, contrast, and functionality. These smart pixels consist of two-dimensional arrays of high-performance specialized electronic circuits that receive optical inputs and provide optical outputs.

A continuing trend in the advanced packaging of electronics is toward the introduction of optical interconnects for large numbers of high-bandwidth connections. Such optically interconnected electronics have been proposed for use in MCM-to-MCM and board-to-board interconnects. The use of these free-space interconnects is particularly attractive as massive parallelism (10,000 channels) is then possible. This gives a new architectural freedom in partitioning systems to avoid the communications bottleneck found in large high-performance computing and switching systems.

Although there has been a large emphasis on evolving optics and optoelectronics into the mainstream of digital computing and switching systems through the optical interconnection of electronics, there is still a need for special coprocessor applications that can be realized with the more traditional optical analog computing structures or optical neural networks.

Finally, as much of the technology associated with optical computing and photonic switching has moved from basic to applied research, so has the need to build feasible system demonstrators. This is a necessary development in the growth of the technology as it forces the development of the new packaging techniques, thermal management schemes, advanced architectures, etc. that will be required before any of these new technologies can be part of successfully manufactured products.

The thirty papers in this special issue are representative of the trends discussed above. These papers have been categorized into six subject areas: optoelectronic digital devices (five papers), optical interconnects (eight papers), neural computing (four papers), analog computing (four papers), architectures (six papers), and system demonstrators (three papers). Although these papers represent significant progress in the field, there is still a large amount of basic, applied, developmental, and manufacturable research required before these optical and optoelectronic technologies can emerge as the dominant technologies for which they hold promise.

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