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Preface

Digital optical computing has come to represent many things to many researchers over the past 25 years. To some the goal is to build a general-purpose, fully programmable, all-optical digital computer, while to others the goal is to introduce optical technologies in an increasing number of functional blocks of a digital computing system. In the early 1960s a number of research projects were undertaken in the United States and the Soviet Union to utilize the newly discovered semiconductor laser diodes and the nonlinear phenomena of saturable absorption in performing digital logic. The premature state of optoelectronic technology (cw semiconductor lasers had to be operated at 77 K) and a critical study of power dissipation-speed trade-off for optical logic led many to conclude that the inherently higher switching speeds of optical phenomena could not be exploited to build digital optical computers that would be competitive with competing electronic technology. These negative factors, coupled with the spectacular developments in electronic integrated circuit technology, led to a downturn in digital optical computing research until the early 1980s.

The second phase of digital optical computing research started in the early 1980s and was spurred by the rapid improvements in optoelectronic technology. New materials [multiple quantum wells (MQWs)] and device configurations [self-electro-optic effect devices (SEEDs), surface-emitting laser arrays] were developed. Technology to integrate optical and electronic functionalities on a single chip also progressed very rapidly. Conversely, the increasing density of high-speed components on IC chips has highlighted the inherent difficulties of communicating high-bandwidth information electrically over long (relatively) distances with high signal density. This prompted an intensive investigation into the use of optical technology for providing interconnections in high-speed electronic systems. The introduction of optical disks for digital data storage has made the presence of optical components in a digital computer more acceptable. Paralleling these developments in hardware, some unique architectural concepts that exploit the global interconnect capabilities of optics have been proposed in the past five years. The combination of all these factors has led to a renewed interest in digital optical computing technology.

The Critical Review conference on Digital Optical Computing was organized to provide a snapshot of several important aspects of this multifaceted field. The sixteen papers in this volume represent a comprehensive overview of all the important aspects of digital optical computing. The papers are divided into two groups: the first dealing with the materials and device technologies for switching, interconnects, and storage; and the second dealing with architectural aspects of digital optical computing. These two aspects of digital optical computing are, however, very tightly coupled. This coupling is most evident where the research in hardware and architectures is performed within the same organization, although a closer examination of the papers in this volume by the reader will reveal a similar coupling between these groups of papers.

The dominant impression left by the papers in the following pages is that optoelectronic technology has indeed reached a level of maturity that will allow a complex systems-level demonstration within the next three to five years. That demonstration could be in the form of chip-to-chip free-space optical interconnects, complex optoelectronic integrated circuits embedded in a high-speed digital system, a parallel optical cellular array machine, or a parallel processor with reconfigurable optical interconnects. Whether any of these demonstrations can be called a true demonstration of a digital optical computer may be more a question of semantics than a question about the valid role optical technology will play in future high-speed digital computing systems.

Acknowledgments

It is indeed gratifying to have contributions from a group of distinguished researchers whose work is defining and advancing the research in the field of digital optical computing. Each of them devoted a substantial amount of time and effort to presenting and writing these papers, for which I am ever so thankful to them. Financial support from NASA's Jet Propulsion Laboratory (Dr. Carl Kukkonen) and Rome Air Development Center's Photonics Laboratory (Dr. Richard Michalak) is gratefully acknowledged. The consistent and steady administrative support of the staff at SPIE has played a critical role in bringing this volume in its present form to you.

George Mason University
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Ravi Athale