Micro-Opto-Electro-Mechanical Systems

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Recent industrial demands in the fields of microsystems and device miniaturization led to development of two major technologies, micro-electro-mechanical (MEM) and micro-optics. A promising team-up of these two technologies combined with microelectronics creates a rich enabling technology of micro-opto-electro-mechanical (MOEM) systems. All constituent technologies in MOEM allow for batch processing and embossing and include a micromachining process that makes them highly fascinating for commercial applications. The MOEM technology is so advanced that in the near future it will lead to the development of a new family of miniaturized devices with enormous potential to revolutionize photonic systems. What makes this technology attractive to industry is its inherent potential for low-cost batch production and miniaturization.

One of the team technologies of MOEM is micro-optics, which has advanced rapidly during the past seven years. Micro-optical components, such as diffractive (binary optics) and refractive microlenses, have recently received considerable attention in the optics research and development community. Micro-optical functions such as focal plane optical concentration for efficiency enhancement, beam combining, and beam shaping have demonstrated the capability of this technology. Optical devices that were considered to be impractical due to the limitations of bulk optics in the 1970s were designed and fabricated easily using micro-optics in the 1980s. The first collection of papers in micro-optics appeared in a special section of *Optical Engineering* in November 1994 (Vol. 33, No. 11). In this special section, the glory and potential of MOEM systems were thoroughly reviewed.

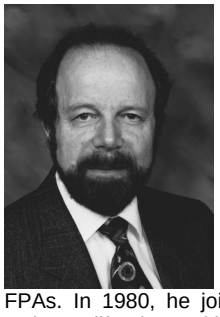
In January 1995, the first SPIE conference related to MOEM systems was held. The conference title was ''Miniaturized systems with microoptics and micromechanics.'' Because of growing interest in this field (see *Proceedings of SPIE*, Vols. 2383, 2687, 3008, 2641, and 2881), SPIE planned for a program track under MOEM systems. Presently, this program contains five conferences all related to MOEM systems. The program also includes a yearly panel discussion that provides an informal forum for defining goals for future conferences to promote the required technologies in developing low-cost, lightweight, and robust devices for both commercial and military applications.

This special section includes 15 selected papers to provide a gear toward aligning the advanced technologies of micro-optics and micro-electro-mechanical systems, and includes advances in miniaturized optical scanners and deformable mirrors. The special section starts with a review paper discussing the entire field of MOEM systems, including the most recent technology advances in micro-optical bench and digital videos. Since MOEM systems include mechanical components, residual stresses in composite structures play an important role for manufacturing reliable devices. Therefore, one paper in the special section is devoted solely to MOEMS material characterization.

In addition, this special section addresses various aspects of MOEM technologies. It is an opportunity for scientists, researchers, and engineers working either in micro-optics or MEMS to collect information that will lead to developing devices for commercial or dual-use applications.

To conclude, it has been a great pleasure to have the opportunity to introduce this new field to all scientific groups of SPIE, IEEE, and especially the MEMS community. We hope the papers presented in this special section will contribute to a better understanding of the status and prospects of MOEM systems. This collection of technology information will support the formation of a very powerful and enriched MOEMS design tools teaming of three technologies: electronics, mechanics, and optics. My thanks to all the authors who have reported their research in the field of optical MEMS. Many thanks are also due to all the members of the editorial board and referees who have diligently sought out the authors and helped in timely publication. I also thank Brian Thompson, Editor of this journal, for giving me this opportunity to serve as the guest editor for such an important and emerging field of photonic systems.

May you all find device miniaturization by MEMS to be a new industrial vision in the 20th century. Teaming MEMS with micro-optics will revolutionize this vision.



M. Edward Motamedi is a senior scientist at Rockwell Science Center. He received his MS and PhD in electrical engineering in 1967 and 1971, respectively, from Northwestern University, Evanston, Illinois. He has more than 25 years of experience in the research and development of VLSI technology, micromachining, and micro-optics. From 1971 to 1979, his academic and research activities were in the development of SAW integrated sensors, CMOS, CCDs, and FPAs. In 1980, he joined Rockwell Science Center, Thousand Oaks, California, working on the development of advanced micromachining. He reported the first VLSI monolithic silicon SAW convolver in 1985, and in 1987 the first monolithic silicon microaccelerometer using MEM technology. In 1989 he was assigned by Rockwell Science Center to develop a start-up technology for micro-optics with the collaboration of MIT Lincoln Laboratory. His recent achievements in micro-optics are: development of high-speed binary optics and refractive microlenses; optical transformers; optical scanners; and FDDI switches. He is a leader in the development and implementation of micro-optic, micro-electromechanical devices, and integrated sensors. He has worked on the IEEE Ultrasonics Symposium Committee for the past 14 years. He is currently a program chair for SPIE for MOEM systems, and since 1995 has served as a chair at SPIE conferences on ''Miniaturized systems with micro-optics and micromechanics,'' and ''Microelectronic structures and MEM devices for optical processing'' for the past four years. He was a guest editor of the IEEE journal of UFFC for a special issue on acoustic sensors and he is an editor of six SPIE proceedings and a coauthor of a book *Semiconductor Sensors.* He received the 1987 IEEE recognition award. He is a member of SPIE, and a senior member of IEEE. He has six U.S. patents and more than 90 papers, including numerous invited papers.