2007-2008 IEEE-LEOS Distinguished Lecture

VLSI Photonics: Visions, Challenges, and Progresses

Prof. Dr. El-Hang Lee, Director
OPERA (Optics and Photonics Elite Research Academy)
National Research Center of Excellence for VLSI Photonic Integration Technology
Micro/nano-Photonics Advanced Research Center (m-PARC)
Graduate School of Information and Communication Engineering
INHA University, Incheon, 402-751, South Korea
ehlee@inha.ac.kr ; www.opera.re.kr

Abstract

This lecture presents a comprehensive review and overview on the cutting-edge frontier science and engineering of micro/nano-photonic integration for VLSI photonic application. It discusses on the theory, design, fabrication, and integration of micro/nano-photonic devices, circuits, chips, and networks in the form of "VLSI photonic integrated circuits"(VLSI-PICs) and "optical micro/nano-networks (O-MNNs)" of generic and application-specific nature on a platform that we call "optical printed circuit boards" (O-PCBs). These systems are designed to be compact, intelligent, high-speed, light-weight, environmentally friendly, low-powered, and low-cost as applicable for datacom, telecom, transportation, aero-space, avionics, bio/medical, sensor, and environmental systems. The O-PCBs, VLSI-PICs and O-MNNs process optical signals through optical wires whereas the traditional E-PCBs, VLSI-ICs, and electrical networks process electrical signals through electrical wires. The VLSI photonic systems are designed to overcome the limitations of the VLSI electrical systems and are also designed to integrate convergent IT/BT/NT micro/nano-devices, circuits, and chips for broad based applications and usages. The new optical systems consist of 2-dimensional planar arrays of optical wires, circuits and devices of micro/nano-scale to perform the functions of sensing, storing, transporting, processing, switching, routing and distributing optical signals on flat modular boards or substrates. The integrated optical components include micro/nano-scale light sources, waveguides, detectors, switches, modulators, sensors, directional couplers, multi-mode interference devices, AWGs, wavelength filters, micro-ring resonator devices, photonic crystal devices, plasmonic devices, and quantum devices, made of polymer, silicon and other semiconductor materials. Some molecular devices are also considered. We discuss scientific and technological issues, challenges, and progresses regarding the miniaturization, interconnection and integration of micro/nano-scale photonic devices, circuits, and networks leading to ultra-small and very large scale integration and discuss their potential applications mentioned above. The issues include the compatibility issues between micro/nano-devices such as materials mismatch, size mismatch, mode mismatch, optical mismatch, mechanical/thermal mismatch and the nano-optical effects such as micro-cavity effects, non-linear effects, and quantum optical effects in nano-scale devices. Scaling rules for the miniaturization and integration of the micro/nano-photonic systems will also be discussed in comparison with those of the micro/nano-electronic systems. New physics, visions, issues and challenges of the optical micro/nano-optical circuits, networks and systems will be discussed along with the historical perspectives of the electrical technology. Recent progresses and examples will be presented along with the future outlook.

Bio-Summary (Prof. Dr. El-Hang Lee)

Prof. El-Hang Lee received B.S. in Electrical Engineering (summa cum laude; Top of the Class), from Seoul National University, Korea, in 1970, and subsequently received M.S., M.Phil., and Ph.D. degrees in Applied Physics from Yale University in 1973, 1975 and 1977, respectively, under the guidance of Prof. John. B. Fenn (Yale Nobel Laureate, Chemistry, 2002) and Prof. Richard. K. Chang (Henry Ford II Professor, former student of Prof. N. Bloembergen, Harvard Nobel Laureate, Physics, 1981). Prof. Lee then conducted teaching, research and management at Yale, Princeton, MEMC, AT&T Bell Labs., ETRI (vice president), Korea Advanced Institute of Science and Technology, and recently at INHA University. Prof. Lee has been the Founding Dean of the School of Communication and Information Engineering; the Founding Dean of the Graduate School of the Information Technology; the Founding Director, OPERA (Optics and Photonics Elite Research Academy) and m-PARC (micro/nano-Photonics Advanced Research Center) at INHA; Vice President, Optical Society of Korea; the Founding President, IEEE-LEOS Korea; and the Founding Director, SPIE-Korea. Published over 230 international refereed archival SCI-covered journal papers; Over 640 international presentations and proceedings; Over 100 plenary, keynote, and invited talks in international conferences; Edited three international proceedings; and hold over 120 international patents; in the field of semiconductor physics, materials, devices, optoelectronics, photonics, and optical communication. Prof. Lee has served for more than 80 times as the leading international conference chair, committee member, and advisor. Prof. Lee is a Fellow of the IEEE (USA), IEE (UK), OSA (USA), SPIE (USA), APS (USA), KPS (Korea), IEEK (Korea), and the Life Fellow of the KAST (Korean Academy of Science and Technology). Prof. Lee is a recipient of more than 20 national and international awards, including the Presidential Medal of Honor (Science), Korea; King SEJONG Award, Korea; Grand Science Award, Korea; and the IEEE Third Millennium Medal, USA. Prof. Lee is listed in many of the Who's Who Books of the World.