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VLSI Photonics:
Science and Engineering of Micro/Nano-Photonics

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 Technology and Telecommunications
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)

B.S.E.E. (summa cum laude), Seoul National University, Korea, 1970; M.S., M.Phil., and Ph.D., Applied Physics, Yale University, 1973, 1975 and 1977, respectively, under 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). Conducted teaching, research and management at Yale, Princeton, MEMC, AT&T Bell, ETRI (vice president), KAIST, and at INHA in the fields of semiconductor physics, materials, devices, optoelectronics, photonics, and optical communication. Distinguished Professor and Founding Dean, School of Communication and Information Engineering; Dean, Graduate School of the Information Technology and Telecommunications; Founding Director, OPERA (Optics and Photonics Elite Research Academy) and m-PARC (micro/nano-Photonics Advanced Research Center); Vice President, Optical Society of Korea; Founding President, IEEE-LEOS Korea; Founding Director, SPIE-Korea. 250 international refereed SCI-covered journal and review papers; 640 international conference presentations; 100 plenary, keynote, and invited talks in international conferences; Edited books and international proceedings; 120 international patents; 100 services as international conference chair, committee member, and advisor. Fellow of the APS (USA), IEEE (USA), IEE (UK), OSA (USA), SPIE (USA), KPS (Korea), IEEK (Korea), and Life Fellow, Korean Academy of Science and Technology. 20 national and international awards, including the King Se-Jong Award, Grand Science Award, and the Presidential Medal of Honor (Science), Korea; the IEEE Third Millennium Medal and the 2007 IEEE/LEOS Distinguished Lecturer Award, USA. Currently, Editor-in-Chief, Photonics Technology Letters.

Contact Information

Prof. Dr. El-Hang Lee
Distinguished Endowed- Chair Professor, Graduate School of Information Technology
Director, OPERA National Research Center for VLSI Photonics
INHA University
253 YongHyun-Dong, Nam-Ku
Incheon City, 402-751, South Korea
Phone (office): +82-32-860-7764, +82-32-860-8845
Fax (office): +82-32-865-8845
Cell Phone: +82-10-6513-3472
E-mail: ehlee@inha.ac.kr
Home Page: www.opera.re.kr or www.inha.ac.kr