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Introduction

This volume features contributions from scientists and engineers in the areas of smart photonic integrated circuits (PIC) and optoelectronic integrated circuits (OEIC), together referred to as smart photonic and optoelectronic integrated circuits (SPOEIC). Photonic, optical, electronic, optoelectronic, photovoltaic, microwave, biological, and fluidic devices are integrated monolithically or using hybrid solutions to address the need for rapid progress in cost, space, performance, and reliability in an increasingly complex and connected world with dynamic environments that can benefit from smart solutions comprising integrated micro- and nano-scale circuits with artificial intelligence.

Demands for greater bandwidths have driven the telecom and datacom research and development communities to realize complex optoelectronic integrated circuits such as transceivers, switching systems, low chirp optical sources, and multichannel optical distribution systems. The integration of multi-wavelength laser arrays, monitoring photodiodes, and drivers is becoming a reality in the communications arena. Other emerging fields include 3D time of flight (TOF) sensing/scanning, real-time 3D imaging/mapping, 3D printing, holographic displays, smart pixel arrays, neural networks, optical computing, optical data storage, medical diagnostics, chemical/biological sensing, and object detection, tracking, identification, and classification.

The increased level of integration in recent years has resulted in an increased level of miniaturization, so we covered in this volume the emerging field of smart VLSI PICs, nanoscale and quantum OEICs, systems on a chip, as well as electronics and photonics convergence on a silicon CMOS platform.

The scientific and technological issues and challenges concerning the micro/nano/quantum-scale integration of optoelectronic devices, circuits, components, modules, subsystems and systems include the size effect, proximity effect, energy confinement effect, microcavity effect, single photon effect, optical interference effect, high field effect, noise effect, quantum optical effect, nonlinear effects, and chaotic noise effects. Optical alignment between miniature devices, minimizing interconnection and coupling losses, maintaining optical modes between devices, and maintaining the stability of optical interfaces, are some of the important issues that are receiving careful consideration.

Papers in these proceedings include discussions of the physics, theory, design, modeling, simulation, and scaling of a wide range of smart PICs and OEICs with regard to their optical, electrical, thermal and mechanical properties; the integration of different optoelectronic structure types including dots, wires, rings, disks, spheres, cavities, wells, planar, free space, one-dimensional, two-dimensional and three-dimensional photonics crystals, plasmonics and

metamaterials; the integration of different functions including lasers, amplifiers, detectors, sensors, solar cells, modulators, isolators, circulators, electrically-actuated/all-optical switches, attenuators, phased arrays, couplers, multi/demultiplexers, filters, wavelength converters, polarization controllers, chromatic/polarization mode dispersion compensators, intra-chip/chip-to-board/board-level optical interconnects, and control electronics; the fabrication, processing, and manufacturing techniques (UV/deep UV/X-ray/e-beam lithography, casting, molding, embossing, etching, passivation, etc.) as well as the packaging, assembly, reliability, qualification and certification of monolithic and hybrid OEICs and PICs in a variety of materials (semiconductors, glasses, polymers, ferroelectrics, magnetics, metals, biomaterials, etc.).

Applications include communications, quantum information services, computing, data storage, sensing, scanning, imaging, mapping, displays, printing, industrial automation, and robotization. Smart systems include nodes in self-healing optical communication networks, as well as light detection and ranging (LiDAR) sensing systems with object detection, tracking, identification, and classification capability for autonomous vehicles.

Some papers describe the refinement of existing schemes and processes, while others introduce novel concepts and new designs. Papers from academic and research institutions push the state of the art in miniaturization, level of integration, and performance figures of merit, and papers from the industry emphasize design criteria and manufacturing methods that result in practical OEICs and PICs that can be deployed commercially today or in the near future.

Although this volume cannot include all the recent important work in the vast field comprising OEICs and PICs, it does cover a significant cross-section of the advances happening globally in areas where these components are making an impact, and it provides a roadmap to the future of OEICs and PICs by presenting the cutting-edge work and the visions of leading experts who are actively inventing the future.

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