PHOTONICS Research

Nonlinear integrated photonics

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The field of nonlinear photonics is in full development. This special issue of Photonics Research takes you through the current issues of this fast-growing field of research, drawing on the current state of the art and seeking, through a selection of articles, to outline some trends for the future.

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Nonlinear optics is in fact a rather old field of research and investigation, but the rapid progression of photonic integration platforms in recent years has opened up a new field of possibilities because of the tenfold possibilities of confining optical fields, and therefore of the reinforcement of light-matter interactions. This fact, combined with the continued progress of experimental means such as accessibility to ultra-fast laser sources, has contributed to the growth of the research activities devoted to the physical properties of nonlinear optical effects in integrated platforms. On the other hand, the field of interconnections and short-distance optical communications, receivers for telecoms, and labs-on-a-chip have a growing need for integrated solutions involving non-linear effects. The rise of information rates, the all-optical processing of data, and the creation of broad spectral sources for on-chip optical spectroscopy in the telecom window or the mid-infrared are just a few examples of the very wide possibilities offered by nonlinear on chip photonics.

Of course, all this cannot be done without challenges or difficulties, and this is what this special issue of Photonics Research seeks to discuss, drawing on the current state of the art and seeking, through a selection of articles, to outline some trends for the future.

As can be seen in the readings of the 11 articles of this special issue, the progress of this burgeoning field is sought either on the side of nonlinear optical properties of materials (no less than six families of materials are explored: Si-rich, GaP, AlGaAs, Si-carbide, hybrid polymers, chalcogenides) or disruptive concepts from the judicious use of nonlinear functions or advanced methods of inverse simulation of nonlinear properties.

The article by Tan *et al.* explores the path of Si-rich materials, based on a natural compatibility with CMOS circuits, and demonstrates impressive performances of these materials for a non-linear photonic integration in the telecom band. Martin *et al.* draw interest in the nonlinear properties of GaP photonics and demonstrate impressive possibilities of cascaded four-wave-mixing, comb generation, and high-order solition generation. In a similar purpose but relying on different material approaches, Allioux *et al.* and Li *et al.* report key achievements in the study of Si-carbide micro-disks and soft materials on silicon hybrid integration, respectively. Second harmonic generation is thoroughly explored in AlGaAs photonic structures by Rocco *et al.*, leading to device-to-system unambiguous results, while Serna *et al.* explore an interesting facet of the nonlinear properties of GeSbS chalcogenide materials at telecom wavelengths. Advanced concepts, combining the use of near-epsilon-to-zero materials and nonlinear properties, are explored by Neira *et al.*, while Bao *et al.* explore in an equally original way but in a completely different field, the possibilities of highly coherent type-II micro-combs based on microresonators. On their side, Da Ros *et al.* and Xu *et al.* expore the current possibilities of investigating non-linear on-chip functions or their use for the realization of dual wavelength conversion signals and photonic microwave true time delays, respectively. Last but not least, this special issue program ends by the work of Sitawarin *et al.* that outlines the possible tremendous progress of nonlinear photonic design based on the combination of optimization methods and inverse problem design concepts.

To summarize, the field of nonlinear photonics is in full development, driven by the scientific curiosity of

physicists who have new integrated platforms and by applications (datacom, optical interconnections, sensing, etc.) whose development needs are increasingly more urgent. This special issue of Photonics Research takes you through the current issues of this fast-growing field of research and, through the 11 articles, to see various facets of it.

We wish everyone good reading and hope that this issue will be a source of inspiration and/or exchange in the photonics community.