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Special Section on Glass Photonics for Integrated Optics

Maurizio Ferrari
Stefano Taccheo

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Maurizio Ferrari
CNR-IFN
CSMFO Laboratory
Trento, Italy
E-mail: maurizio.ferrari@ifn.cnr.it

Stefano Taccheo
Swansea University Singleton Park
College of Engineering
Swansea, United Kingdom
E-mail: S.Taccheo@swansea.ac.uk

Integrated optics is the field where photonics and glass science smartly cooperate to develop new physics, new devices, and new applications. Glass materials and photonic structures are the cornerstones of scientific and technological building in integrated optics. Photonic glasses, optical glass waveguides, planar light integrated circuits, waveguide gratings and arrays, functionalized waveguides, photonic crystal heterostructures, and hybrid microresonators are some examples of glass-based integrated optical devices that play a significant role in optical communication, sensing, biophotonics, processing, and computing.

This cross-disciplinary approach leads to constructed luminescent structures that can perform sensing and functionalized structures to successfully address socioeconomic challenges, such as security, cost-effective healthcare, energy savings, efficient and clean industrial production, environmental protection, and fast and efficient communications. Photonics, with its pervasiveness, has already been identified as an enabling technology, and through advanced research in glass-based integrated optics systems, photonics can contribute to finding new technical solutions to still unsolved problems, and pave the way to applications not yet imagined. Looking at this picture, the aim of this special section is to provide insight into state-of the art and future trends on the fabrication, characterization, and application of modern glass-based materials and integrated optic structures.

A further aim is to underline all the possible convergences, synergies, and interaction among topics and scientific fields, and to provide a common framework for research on glass-based integrated optics.

The full set of papers submitted for publication in this special section were high in number and truly excellent in science, and all papers were subject to rigorous peer review. The result of the process is represented by the present special section, which includes 23 papers providing a broad overview of state of the art in this cross-disciplinary field. The presented articles provide insight into fundamental principles and modeling, fabrication, processing, characterization, and exploitation of optical glasses and photonic structures for the intelligent management of light in the framework of integrated optics. Several materials such as oxides, fluorides, telluride, and boron–based glasses and films are discussed in this special section, as well as systems and devices ranging from fiber lasers to waveguides and sensors, with an eye on nanocrystals, glass ceramics, and nanoceramics. We summarize the large amount of information the reader will be able to find in this special section below.

Modeling is a key aspect of integrated optics, and several papers discuss different aspects of the physics of integrated optics. One paper deals with the structural diagram and the operation principles of an integrated optical temperature sensor based on waveguides. Another paper deals with design, simulation, evaluation, and technological verification of various low-index optical demultiplexers based on arrayed waveguide gratings. The crucial problems relating to the coupling of the light in spherical microresonators are discussed in another paper looking at the design of fiber-coupled Er^{3+} chalcogenide microsphere amplifiers via particle swarm optimization algorithm. The experimental counterpart regarding spherical microresonators is described in a paper where barium fluoride and lithium fluoride whispering-gallery-mode resonators are demonstrated to be a viable systems for photonics applications. Another paper describes a computational approach for the optical characterization of an opal photonic crystal, and the numerical results show good agreement with the experimental data. This is fundamental to be able to make an exhaustive analysis of the field distribution inside the crystal. In the same theoretical approach, the light Bloch oscillations in the array of optical waveguides are investigated based on the electrodynamics of continual approach. The important parameters governing a two-wave directional coupler, in the conceptual frame of coupled single-mode planar waveguides, are studied by an analytical model where the modal relation of dispersion is expressed exactly under a matrix form.

As expected, many of the papers are experimentally oriented and concern fabrication techniques, spectroscopic characterization, and specific research about novel materials and evaluation approaches. In this framework we have an open access review paper on fabrication techniques of glass optical waveguides to provide the reader an exhaustive overview of this important topic.

A set of papers deal with glass-based confined structures fabricated by sol-gel and radio-frequency sputtering, as well as with host and growth techniques to develop laser materials in the 2-μm spectral region. Micromachining is a specific technique with enormous potential and is discussed in several papers regarding waveguide arrays fabrication for light harvesting in microfluidic chips, fabrication of metal nanostructures in a polymer matrix using a femtosecond laser writing technique, and Fresnel lenses fabricated by femtosecond laser micromachining on polymer one-dimensional photonic crystal. Another important topic is research on new glasses, eventually able to support new wavelength operation. Two significant experimental papers are devoted to chalcogenide glasses, one concerning nonlinear optical response and heating of chalcogenide glasses upon irradiation by the ultrashort laser pulses and the other regarding versatile hot embossing of midinfrared glasses for on-chip planar waveguides for molecular sensing in midinfrared integrated optics. Materials, as mentioned above, are crucial in developing integrated optics systems, and the optical properties of photonic devices largely depend on the dielectric properties of the underlying materials. A detailed study concerning dielectric properties of different phases of SiO_2 is discussed in this special section pointing out the importance of the electronic and ionic contributions to the dielectric constant in the different energy regimes. New glasses and structures to construct waveguide sources of radiation in the wide infrared range are presented in a study devoted to broadband near-infrared emission in antimony-germanate glass co-doped with erbium and thulium ions. Use of glasses for frequency conversion is a further topic that may impact green energy production, and a paper is devoted to rare earth–doped fluoride glasses as a medium for integrated optics up-converters waveguides for up-conversion of visible emission.

A glass-polymer superlattice for integrated optics fabricated by pulsed laser deposition is presented in another contribution. Subwavelength structures play a key role in a whole new set of devices, and nowadays nanocomposite materials and nanostructures are among the more innovative constituent of the integrated optic systems. One of the contributed papers looks at structural and optical properties of porous anodic alumina-aluminium nanocomposite films on borofloat substrates. Photonic crystal fibers also prove to be a very promising element for integrated optics application as can be found in two papers, one discussing soft glasses for photonic crystal fibers and microstructured optical components, and the other optical fiber microstructuration for strengthening single-mode laser operation in a high-power regime. Remaining on the topic of integrated optics for sensing, we mention the research on a metal-clad optical waveguide fluorescence device for the detection of heavy metal ions.

Looking at the papers published in this special section, we remark that rare earth–doped glasses still play a crucial role for the development of specific optical components whose characteristics are critical for achieving the flat and broadband optical gain that seems needed in future communication systems. The search for more and more efficient compositions and guiding structures, however, is still open. In fact, the papers presented here show that the research is driven by the exploitation of new materials, the development of innovative and reliable fabrication techniques, and the complementary contribution of specific geometries for light management. Several examples of fabrication of integrated optics structures by conventional techniques as well as by using direct writing processes and other novel methods, have been here reported.

In summary, we believe this special section will be a useful reference for of the state of the current research and for future prospective in glass photonics for integrated optics, as well as an indication that a cross-disciplinary approach will be increasingly important. This special section follows a previous Special Section on Integrated Optics, edited by Giancarlo C. Righini, published in *Optical Engineering* in 2011. We hope that this second topic will be as well received by the community as the first.

Last but absolutely not least we wish to express our sincere appreciation to the staff of *Optical Engineering*, who kindly and very effectively supported us to assemble this valuable special section and smoothly run the editorial tasks. A special thanks to the *Optical Engineering* Editor, Ronald G. Driggers, who believed in this initiative, and the fantastic Karen Klokkevold, Karolyn Labes, and Gwen Weerts, who have lead the construction of this special section and managed all problems.

Maurizio Ferrari received a degree in physics from University of Trento in 1979–1980. Until 1989, he worked as a researcher with the LPCM, Lyon, France, and in 1989 he moved to Trento as a researcher with the CNR. He is currently a senior researcher heading the IFN-CNR Trento unit. He is a Fellow of SPIE. He is coauthor of more than 300 publications and several book chapters, and he is involved in numerous national and international projects concerning glass photonics.

Stefano Taccheo received a degree in nuclear engineering in 1989 from Politecnico di Milano. In 1990 he was a researcher at SIRTI/CSELT Turin. In 1991, he joined Politecnico di Milano where he became an associate professor in 2004. Since 2008, he has been an associate professor at Swansea University. He spent sabbatical years at the Optoelectronics Research Centre-Southampton, United Kingdom, in 1996 and at Lucent Bell Labs, New Jersey, USA, in 1999. His main research interests include fiber, waveguide, and bulk lasers, new active glasses, and laser applications.