Editorial

Tigran Galstian, Réal Vallée and Younès Messaddeq*

Optical materials

https://doi.org/10.1515/aot-2018-0036

Optical materials not only stands as a basic science but also as a key technology that impacts our daily lives. Indeed, this research field is crucial to many areas of the economy with recent major advances in telecommunications, healthcare, energy production and environmental monitoring. For example, optical materials contributed to the advent of ultra-low loss telecommunication optical fibers, which enabled the Internet revolution.

Although optical materials are supporting the development of many high-impact technological areas, the evolution of optical and photonic applications has particularly benefited from the contribution of this core technology, which is expected to become more and more ubiquitous in the coming decades. This field of science studies the interactions of light in its wave-photon duality with optical materials and aims at developing techniques to structure and engineer optical materials so that they can reach the capability to alter, control, and manipulate light. If originally, optical materials were primarily used to passively transmit visible light, today, thanks to recent advances in molecular design and synthesis of new compounds, in material processing, in methodologies and instrumentation for the characterisation of materials, we are beginning to witness the emergence of new materials with novel properties capable of acting on light in a controlled manner.

The mastery of matter comes with the abundance of research focused on exploring and compiling the chemical, physical and optical properties of newly synthesized materials. Basic optical properties, such as extended transparency from the UV to the far infrared or nonlinear optical properties and photosensitivity, have been studied extensively. A wide range of materials with improved optical properties such as glasses, polymers and ceramics are actually ready for integration in the next generation of displays, optical fibers, sensors, laser materials and optical devices. Composite, hybrid and nanostructured materials are emerging on the market as prospects for large volume applications (telecom, imaging, etc.) as well as in niche applications (medical, robotics, adaptive vision, etc.). Some of these materials also exhibit biocompatibility, which is particularly attractive for healthcare applications. Organic optical materials have also raised strong interest due to their relatively strong nonlinear optical properties and large volume applications. They are being integrated in optical devices in display, lighting and information processing.

It may improve a property that the lubricant already possesses or give it properties that it does not naturally possess. In addition to the emergence of these new core materials, there is actually a strong trend towards tailoring existing materials in novel ways to produce innovative outcome. These so-called meta- or nano-materials, are materials that can be structured and engineered to show new optical properties that the bulk original materials themselves would not naturally possess. Structuring materials with features less than or close to one wavelength of light can lead to these novel properties and allow the control of optical properties such as spectral and polarization dependence in transmission, refraction, reflection, absorption, and nonlinear emission of light. Photonic crystals are two-dimensional (2D) or three-dimensional (3D) periodic sub-wavelength structures that affect the motion of photons. Since the first publications by Eli Yablonovitch and Sajeev John, co-founders of the field of photonic crystals in 1987, rapid progress has been made on this topic. Photonic crystal devices are being actively deployed in biosensors, semiconductor lasers and hollow-core fibers. One may add metal patterns to such periodic structures to produce negative refractive indices and superlens effects; a properly designed pattern can, for example, focus light below the conventional diffraction limit.

Recently, important new fabrication technologies have begun to emerge, challenging once again the current limits. They have been put to use in the design of innovative

***Corresponding author: Younès Messaddeq,** Department of Physics, Engineering Physics and Optics, Centre d'optique, photonique et laser (COPL), Université Laval, Pavillon d'optique-photonique, 2375 rue de la Terrasse, bur. 2113, Québec (Québec) G1V 0A6, Canada, e-mail: younes.messaddeq@copl.ulaval.ca. http://orcid.org/0000-0002-2918-9711
Tigran Galstian and Réal Vallée: Department of Physics, Engineering Physics and Optics, Centre d'optique, photonique et laser (COPL), Université Laval, Pavillon d'optique-photonique, 2375 rue de la Terrasse, bur. 2113, Québec (Québec) G1V 0A6, Canada

multimaterial or multifunctional materials. As a result, innovative solutions and technologies are now coming to the market. On the one hand, multimaterial and multifunctional components have demonstrated their potential to concurrently offer multiple functionalities like electrical conductivity, piezoelectricity, physical/chemical sensing in addition to light transmission. Complex associations of materials with specific properties in the form of fibers that can be easily integrated or interconnected provide novel solutions to specific problems where the collection and integration of data of different nature is required. On the other hand, ultrafast laser processing of materials, including 3D laser writing, has evolved very rapidly and is currently revealing its technological and industrial potential. Laser writing via two-photon or multiple-photon absorption is becoming a mature technology and its ease of application for 3D printing at a micro-/nano-meter scale is just revolutionary. All these advances allow designing and producing complex structures by taking inspiration directly from nature as, for example, bio-inspired photonic materials.

This special issue could simply not address the entire broad field of science and applications of optical materials. For such reason, this issue will be divided into two parts. In the current issue, we will have one tutorial, one review and five research articles. The tutorial of Nicholson-Smith about the Parametric Analysis of Thin Multifunctional Elastomeric Optical Sheets illustrates the concept and key design parameters of the controlled light propagation in flexible polymeric sheets. These flexible optical sheets are considered as a new generation of innovative materials that can be used for passive light harvesting and illumination systems.

The review of Doris Ehrt on Exploring Materials for Deep UV provides a large series of materials such as fluoride single crystals, fluoride glasses, fluorophosphate multicomponents, silica and organic materials. The author explains the role of the intrinsic absorption that affects the optical properties of different materials.

Martin Rochette's paper demonstrates All-Fiber Far Detuned and Tunable Mid-IR Wavelength Conversion using chalcogenide microwires. He provides new solutions for the next generation of integrated optical devices operating in the mid-IR.

The Anatoliy paper entitled Frequency-Dependent Electro-Optics of Liquid Crystal Devices Utilizing Nematics and Weakly Conducting Polymers covers the process control and design of optical materials based on liquid crystals.

A paper on the Design of a 1D Phase-Mask Translational Scanner for Large-Size Spatially Coherent Grating Printing by Yves Jourlin explains the process of producing spatially highly coherent gratings on long sheets of large width substrates produced in a continuous way.

Two papers are presented regarding the interaction of light with matter. The paper from Marowsky presents a Comparative Study between Experiment and Simulation of Single Pulse Femtosecond Laser Ablation of Silicon. The second paper by Sandra Messaddeq deals with the Formation of Superposed Structure in As_2S_3 Based Glasses Using fs-Laser. In both papers, original structure is observed at the surface of those materials.

Warm thanks are extended to the authors and reviewers for their time and input as well as to the *Advanced Optical Technologies* team for their valuable support in building this collection of papers.

Tigran Galstian
Department of Physics, Engineering Physics and Optics, Centre d'optique photonique et laser (COPL), Université Laval
Pavillon d'optique-photonique
2375 rue de la Terrasse, bur. 2113
Québec (Québec) G1V 0A6, Canada

Tigran Galstian (or Galstyan) started his studies at Yerevan State University, Armenia (former Soviet Union). He received his MSc (Solid State Lasers) and PhD degrees (Quantum Electronics) from the Special Department of Physics at Moscow Engineering Physics Institute, Russia. He spent several years as a postdoctoral researcher in France and then moved to Canada to join the faculty at the Department of Physics, Engineering Physics and Optics, at Université Laval (Québec). He heads the laboratory of Photonic Materials and Components and at the Centre for Optics, Photonics and Lasers, and holds a Canada Research Chair in Liquid Crystals and Behavioral Biophotonics. His main research interests are in self-aligned molecular systems and their applications in electro-optic materials and biology. His group is investigating the molecular self-organization mechanisms and their impact on key material properties as well as their influence on the behavior of light (focusing, divergence and color), molecules (diffusion of chiral 'medical' molecules) and living microorganisms (bacteria).

Réal Vallée
Department of Physics, Engineering Physics and Optics, Centre d'optique photonique et laser (COPL), Université Laval
Pavillon d'optique-photonique
2375 rue de la Terrasse, bur. 2113
Québec (Québec) G1V 0A6, Canada

Réal Vallée received his PhD in physics from Université Laval in 1986. He then joined the Laboratory for Laser Energetics, at the University of Rochester as a Postdoctoral Fellow. In 1989, he returned to Université Laval to begin his career as a Professor in the Department of Physics. In 2000, he was appointed Director of the Center for Optics Photonics and Lasers (COPL), a position he holds to this day. His research interests center on optical fibers, optical components and their applications, visible and infrared fiber lasers, non-linear effects, short pulse propagation in fibers, waveguide and Bragg grating writing with femtosecond pulses, and the study of chalcogenide glasses for integrated optics applications. He currently holds an Industrial Research Chair in Femtosecond Photo-Inscribed Photonic Components and Devices. Professor Vallée has authored over 200 papers in peer-reviewed journals and international conferences and holds 12 patents. He is a Fellow of the Optical Society of America. In 2018, he and five of his colleagues were honored with the prestigious Brockhouse Prize for interdisciplinary research. The award recognizes outstanding Canadian teams of researchers from different disciplines who have combined their knowledge and skills to produce a record of excellent achievements in the natural sciences and engineering.

Younès Messaddeq
Department of Physics, Engineering Physics and Optics, Centre d'optique photonique et laser (COPL), Université Laval Pavillon d'optique-photonique
2375 rue de la Terrasse, bur. 2113
Québec (Québec) G1V 0A6, Canada
younes.messaddeq@copl.ulaval.ca
http://orcid.org/0000-0002-2918-9711

Younès Messaddeq received his PhD in Chemistry from Université de Rennes 1, France. He was professor and research group leader at the Institute of Chemistry of Araraquara (UNESP, Brazil) before joining the Department of Physics, Engineering Physics and Optics at Université Laval (Québec) in 2010. He holds the Canada Excellence Research Chair in Photonic Innovations. He is a world leader in the study and development of photonic materials, he heads a 40-member team of graduate students and research staff on low loss mid-infrared glasses, microstructured and multifunctional optical fibers and nanostructured materials for applications in health, agriculture, communications and defence and security. He has authored over 400 publications and holds more than 30 patents. Prof. Messaddeq has spearheaded various research and training initiatives that have resulted in the establishment of the International Joint Unit with the University of Sao Paulo (UNESP) in Brazil and the International Associated Laboratory on light-matter interactions involving the CNRS and Université de Bordeaux in France, and Université Laval and INRS in Canada. He also played a key role in securing the largest grant ever awarded to Université Laval for the Sentinel North program. In 2018, the Government of Canada awarded him and five other colleagues the prestigious Brockhouse Prize for interdisciplinary research in science and engineering.