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Non-Oxide Optical Materials: introduction to the special issue

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Abstract: This is an introduction to the feature issue of *Optical Materials Express* on *Non-Oxide Optical Materials*.

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Non-oxide glasses and crystals are important optical materials due to their infrared (IR) transparency, high refractive indices, and “tunable” properties (through doping or alloying). The combination of these properties means that non-oxide materials are used in a vast array of current and developing technologies. This feature issue highlights recent advances in non-oxide optical materials such as chalcogenides, halides, and nitrides, dealing with everything from basic glass chemistry, issues related to their integration as components into systems, from all-optical switching to lab-on-a-chip photonics. We’ve emphasized publication of papers from a global set of authors: of the twelve papers accepted for publication, the authors represent eight different countries. We’ve also worked to illustrate the breadth of this field; the papers in this issue cover the basic optical and thermal properties non-oxide glass (chalcogenide and fluoride) and ceramic families designed as well as approaches for using all of these materials in advanced optical devices.

Cook et al. discuss the incorporation of optically active nanoparticles into chalcogenide glass matrices in order to progress the state of on-chip mid-IR lasing. These advances open up pathways to on-chip lasing at wavelengths greater than 4 microns, for which there are very few current options [1]. Wachtel presents new results on the optical dispersion of a wide range of germanium-arsenic-selenide glasses. Incorporation of these non-standard glasses into the optical designer’s toolbox opens up the creation of novel lens geometries and functionalities [2]. Wang and coworkers present new results on the linear and nonlinear optical properties of the family of $\text{GeS}_2\text{-Sb}_2\text{S}_3\text{-CsCl}$ chalcogenide glasses. Based on their high nonlinear refractive indices, these materials are promising for use in two-photon absorption (TPA)-based photonic devices and should operate well as optical limiting materials [3]. Mochalov et al. explore the complex chalcogenide glass system $\text{PbS}_{1-x}\text{Se}_x$ formed in thin films through the use of plasma-enhanced chemical vapor deposition (PECVD) to control the stoichiometry and phase composition. These materials are promising both for their use in highly sensitive mid-IR photodetectors, but also in room temperature thermoelectric devices [4]. Loretz et al. present a big data, algorithmic approach for the prediction of chalcogenide glass densities across more than 40 glass families. These results challenge the approach of relying on Mean Coordination Number (MCN) for prediction of macroscopic properties [5].

Xu introduces ZYBA, a new fluorozirconate composition that has superior chemical and thermal stability to the standard ZBLAN formulation. The group demonstrates the lasing properties of ZYBA through creation of a whispering gallery mode resonators doped with a variety of rare earths. ZYBA exhibits properties that make it very competitive for use in high-powered mid-IR fiber lasers [6]. Yao and coworkers present a new fluorotellurite composition: TBY, also for use mid-IR laser applications. They explore the laser damage threshold of this novel composition under femtosecond irradiation in the 3000–4000 nm range [7]. Zhang presents a review of the application of heavy metal fluoride glasses (including ZBLAN) in next-generation optical fiber applications. This group discusses the evolution of structure, glass compositions, and optical fiber draw processes since the 1980s and focus on the use of these fluoride glasses in both mid-IR lasing as well as supercontinuum generation applications [8].

Li and coworkers demonstrate a hot embossing technique for forming pyramidal structures on IR glass surfaces to serve as broadband anti-reflective (AR) structures. These structures increase transmission of the high-index substrates by 7–11% across the 5–15 μm waveband [9]. Yelliseyev et al. explore the patterning of GaSe crystal surfaces to create antireflective microstructures (ARMs). Laser ablation at 513 and 1064 nm was used to create the ARMs, which showed an improvement in transmission of 12% per patterned side over the waveband of 6–15 microns [10].

Junaid presents results on the development of IR-transparent liquids for optical microfluidic devices. For fiber-based or on-chip microfluidic applications, precise knowledge of the attenuation coefficient of the fluid is critical to the functionality of the device. This study introduces the liquid CBrCl_3 as a promising candidate, combining a large refractive index with broadband transmission up to wavelengths of 6 microns [11].

Dunch and Jackson report on a literature review concerning the theory of optical scattering in transparent glass ceramics (TCGs). TCGs of many base compositions are being explored due to their novel optical properties and their increased toughness (both due to and dependent on the fraction of ceramic crystals). Importantly, their analysis includes the impact of the material's refractive index dispersion on the transmission and scattering properties [12].

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