2:30 PM

(GOMD-185-2021) Investigating femtosecond laser interaction with tellurite glass family

G. Torun*[1]; T. Kishi[3]; D. Pugliese[2]; D. Milanese[4]; E. Descrovi[2]; Y. Bellouard[1]

1. EPFL, Switzerland
2. Politecnico di Torino, Department of Applied Science and Technology and RU INSTM, Italy
3. Tokyo Institute of Technology, Department of Chemistry and Materials Science, Japan
4. Università di Parma, Department of Engineering and Architecture and RU INSTM, Italy

Focusing ultrafast laser pulses induce localized permanent structural modifications on the surface or in transparent materials, that are of particular interest for photonic applications. Among the materials of interest, the tellurite glass family is attractive for near-infrared and photonics applications due to its broad-transparency window and high optical nonlinearity. Here, we systematically investigate structural changes occurring in various TeO_2-based glasses exposed to femtosecond laser with various laser parameters. Remarkably, in a regime where heat accumulated after successive pulses, we observed the formation of polarization-controlled self-organized patterns expanding well beyond the focal volume, suggesting the presence of an evanescent coupling mechanism enhancing the self-organization. In addition, our results, obtained with compositional elemental analysis coupled with Raman spectra suggest different ion migration mechanisms in the laser affected zone at the surface and inside the glass. The formation of crystalline tellurium (t-Te) from glass structural units due to photo-induced elemental dissociation was observed only at the surface. The formation of ultrathin layer of crystalline tellurium offers the possibility to explore structural transitions in two-dimensional (2D) glasses by observing changes in the short- and medium- range structural orders, induced by spatial confinement.

2:50 PM

(GOMD-186-2021) Sub-micrometric femtosecond laser structuring in silver-free and silver-containing gallo-germanate glasses

R. Zaiter*[1]; T. Guerineau[1]; T. Cardinal[1]; Y. Petit[2]; B. Sapaly[3]; J. Harb[2]; L. Canioni[2]; M. Lancry[3]

1. Institut de Chimie de la Matière Condensée de Bordeaux (ICMCB) - Université de Bordeaux, Centre National de la Recherche Scientifique : UPR9048, France
2. Centre d'Études Lasers Intenses et Applications (CELIA) – Centre National de la Recherche Scientifique : UMR5107, Commissariat à l'énergie atomique et aux énergies alternatives : DAM/CESTA, Université Sciences et Technologies - Bordeaux 1, France
3. Institut de Chimie Moléculaire et des Matériaux d'Orsay (ICMMO) – Université Paris Saclay, France

Femtosecond Direct Laser Writing technique (FDLW) has been widely used during the last two decades to perform 3D photo-structuring in glasses such as for PIC (Photonic Integrated circuits). The controlled formation of the photo-induced modifications allows developing remarkable optical properties such as birefringence, photoluminescence, 2nd and 3rd harmonic generation. The understanding of correlations between the glass structure, the laser induced process and the resulting properties remains a tremendous challenge. To explore new opportunity in terms of applications and wavelength ranges, novel vitreous materials need to be explored. Among the different oxide glasses, heavy metal gallo-germanate oxide glasses have attracted attention and lead to a growing interest since they could combine local functionality, extended transparency window in the mid-IR up to 5.5 μm, chemical durability and robust mechanical properties. We report on the formation and structural evolution of embedded self-organized, polarization-dependent nanogratings in gallo-germanates induced by femtosecond laser pulses. Micro-Raman spectroscopy will be used for establishing local structure property relationship. Micro-fluorescence, micro-absorption, phase-contrast imaging, and confocal fluorescence imaging of the FDLW structure will be discussed.

Laser Interactions with Glass III

Room: Saturna Island
Session Chair: Theo Guerineau, University Laval

3:30 PM

(GOMD-187-2021) Formation of Nanoparticles in Glass Under Femtosecond Laser Irradiation

C. Barker*[1]; S. McAnany[2]; K. J. Veenhuizen[3]; D. Nolan[4]; B. Aitken[4]; V. Dierolf[1]; H. Jain[5]

1. Lehigh University, Physics, USA
2. Lehigh University, Materials Science & Engineering, USA
3. Lebanon Valley College, Physics, USA
4. Corning Incorporated, USA
5. Lehigh University, International Materials Institute for New Functionality in Glass, USA

Formation of metal nanoparticles (NP) such as of gold, copper and silver in silicate glass via dissolution of metal salt at high temperature followed by precipitation at low temperature has been known to produce ruby color uniformly for millennia. This method exploits the strong temperature dependence of the solubility and stability of metal ions under near equilibrium conditions. By contrast, recently NPs have been produced in spatially selective regions deep inside the glass by fs laser irradiation under highly nonequilibrium conditions. We report on the formation of Ge NP in La_2O_3-B_2O_3-GeO_2 glass by this method using Pharos 1026 nm wavelength laser focused 90 μm below the glass sample surface using a 50x, 0.6 NA objective lens with a pulse width of 175 fs, and a repetition rate of 200 kHz. It is shown that such NPs form only within a narrow range of pulse power of 2-3 μJ. Structural changes in the glass are characterized for various laser irradiation conditions by X-ray absorption near edge structure, Raman spectroscopy, and electron microscopy. Likely mechanisms for the formation of NPs in glass by fs laser irradiation will be presented.

3:50 PM

(GOMD-188-2021) Structure-Terahertz Properties-Ultrafast Laser Irradiation Correlations in Borosilicate, Tellurite, and Chalcogenide Glasses

N. Tostanoski*[1]; S. K. Sundaram[1]

1. Alfred University, USA

We have studied Na_2O WO_3 TeO_2, La_2O_3 WO_3 TeO_2, and Na_2O B_2O_3 SiO_2 borosilicate and tellurite glass systems, along with additional chalcogenide glass systems, with their chemistries systematically varied within the glass forming region, changing the glass structure, which affects their terahertz properties. We prepared the glass samples via melting and casting, followed by annealing. The glasses were then characterized using differential scanning calorimetry (DSC), x-ray diffraction (XRD), ultraviolet-visible (UV-Vis), Fourier transformation infrared (FTIR), Raman spectroscopy, and time-domain terahertz spectroscopy (THz-TDS). In addition, ultrafast laser pulses (e.g., ~ 40–100 femtoseconds) were used to irradiate these glass samples, modifying the local glass structure and their optical properties. Glass structural changes made via laser irradiation are correlated to terahertz properties of these glasses. Linear correlation between optical and THz refractive indices will be reported for the glass systems. Any deviation from linearity and its origin will be presented.