

Chalcogenide glasses: structural properties and applications in photonics

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Due to their unique properties such as high IR transparency, numerous photoinduced effects, high non-linear optical properties, etc., chalcogenide glasses (CG) are perspective materials for various applications in the modern photonics and nanotechnology. CG are widely used in versatile technological applications for fabrication of optical elements and devices for optoelectronics, holography and information storage media. In present report the investigation results of chalcogenides glasses (CG) structural properties and their applications are reviewed. EDX, XRD, EXAFS, AFM, SEM techniques and Raman spectroscopy were used as tools in studying the structural properties of CG's. As_2S_3 - As_2Se_3 , As_2S_3 - Sb_2S_3 , Ge-As-Se, Ge-As-S, Ge-Sb-Te, Ga-Ge-Te and Ge-S-Ag, Ag-As-S, As_2S_3 : Mn chalcogenide glasses. The experimental X-ray diffraction profiles confirmed amorphous nature of studied glasses. Pair distribution functions and RDF were obtained for samples of As-Ge-Se, As-Ge-S, As-Sb-S glasses and Ga-Ge-Te glasses, As-S(Se) glasses doped with Ag, Mn. The addition of silver and germanium does not significantly affect the position of first coordination sphere r_1 . Radius of first coordination sphere for As-S-Ag glasses correspond to 2.29 Å value, for As-Ge-S glasses – 2.25 Å and for second coordination sphere – 3.48 Å for both glass compositions. Changes of short range order parameters (r_1) of As_2S_3 :Mn glasses with Mn concentration were within calculation errors. In the case of As-Sb-S glasses with the increase of Sb content position of first coordination sphere radius is shifted towards the longer distances (from 2.29 Å to 2.42 Å), positions of the second peaks – 3.45-3.54 Å for studied glasses. Compositional changes in As_2S_3 - Sb_2S_3 alloys have been observed in the evolution of Raman bands. Raman data show that pseudo-binary As_2S_3 - Sb_2S_3 glasses contain different nanophases whose concentration changes along the chosen compositional cross-section. Raman spectra of Ge-As-S samples showed that the backbones of the studied samples consist of $\text{AsS}_{3/2}$ pyramidal units, edge- and corner-shared $\text{Ge}(\text{S}_{1/2})_4$ tetrahedral units. Compositional changes in studied glasses result in the evolution of the observed Raman bands. Such dependences of characteristic constituent Raman bands' intensities showed that Ge-As-S samples contain different nanophases whose concentration is changing along chosen compositional cross-section. For Ag-As-S chalcogenide glasses the main effect that is observed at introduction of silver into nanostructured As_2S_3 glass is the change of the relative concentration of the main and non-stoichiometric molecular structural units. Systematic compositional dependencies of the intensities of the characteristic Raman bands correlate with evolution of concentration of the different structural units in Ge-As-Se, Ge-As-S and Ga-Ge-Te alloys along the studied compositional lines. Observed bands in the Raman spectra of studied glasses show that such glasses contain different nanophases and can be explained in the terms of vibrational modes of the respective binary glasses and films. CG glasses and different structures on their base are promising for application in photonics and optical data storage. Surface patterning using composite nanomultilayer structures on the base of CG by a laser or electron beam with and without chemical etching, attracts high interest. Surface relief holographic diffraction gratings were directly recorded using composite As_2S_3 :Ag/Se nano-multilayered structures. Diffraction efficiency values of the recorded gratings in transmission were ~22%. AFM measurements have shown high quality of the recorded gratings relief's. Process of surface relief formation depended on the polarization of recording light beams. Such media are also perspective for the recording of digital holograms. Reviewed investigation results concerning chalcogenide glasses show that chalcogenide glasses are perspective for various applications in photonics.

Keywords: Chalcogenide glasses, structural properties, Raman, optoelectronics and photonics applications

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