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OPTICAL PROPERTIES OF As-Ge-Se LAYERS

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In present paper the optical properties of As-Ge-Se films in the transparence and absorption edge region were investigated, which were well described by single-oscillator model. Evolution of the single oscillation model parameters under exposure indicated the presence of the photostructural changes, which were directly confirmed by Raman spectra measurements. Considerable level of photostructural changes allows to consider such films as perspective registering media for information recording and production of surface relief.

Keywords: Chalcogenide glasses, optical properties, Raman spectra

1. Introduction

Optical glasses of As-Ge-Se composition due to excellent transmission in IR spectral range, high refractive index values and wide spectra of optical phenomena which can be used for the fabrication of various surface relief are perspective for the use in IR optics, optoelectronics. The layers of chalcogenide vitreous semiconductors (ChVS) are perspective also as registering media for information recording with ultrahigh density due to their amorphous structure. With the use of STM and ChVS as recording media the possibility of information recording with density ~ 1 Tbytes/cm^2 [1]. In present work the optical properties of As-Ge-Se layers are investigated in the transparency and absorption edge regions.

2. Experiment

Thin As-Ge-Se films of $As_{10}Ge_{22.5}Se_{67.5}$ composition (d= 0.7-2 μm) were deposited with the help of thermal vacuum evaporation from quartz or molibdenum boats on the glass substrates at room temperature. Deposition rate was controlled by quartz microbalance and consisted 1-6 nm/s. During sample preparation exposure to light sources was minimal. Samples were kept in complete darkness until measured. Optical properties of layers were obtained in the region 0.4-2.5 μm from the data of optical transmission with the help of the procedure described in [2]. Exposure was carried out by halogen lamp (I = 20 mW/cm^2, IR cut-off filter). Investigations of Raman spectra were carried out with the use of laser excitation on 1.06 μm (FTIR spectrometer IFS-55 with FRA-106 Raman module), laser power consisted 90 and 15 mW during investigation of the glasses and films, respectively. The wavelength of the laser beam was critical to avoid any photostructural changes in chalcogenide glasses and films within the time scale of 100 scans for glasses and 1000 for films. The resolution of the Raman spectrometer was 1 cm^{-1}. All measurements were performed at room temperature.

3. Results and discussion

Spectral dependencies of the refractive index $n(\lambda)$ of $As_{10}Ge_{22.5}Se_{67.5}$ layers in the transparency region were well described within the frames of single-oscillator model (Fig. 1). For the exposed sample the shift towards shortwave side is characteristic. Such "blue" shift was also characteristic for the spectra of the annealed $Ge_X As_{40-X} S_{60}$ and $Ge_{10}As_{15}Se_{75}$ [3-4]. Analysis of the parameters of single-oscillator model (single oscillator energy, E_0, dispersion energy, E_d) shows increase of E_0 and E_d after exposure. The change of E_d can be considered as an indication of the short range order changes under influence of the external factors (exposure). Besides that, the exposure leads to the increase of the optical dielectric constant.

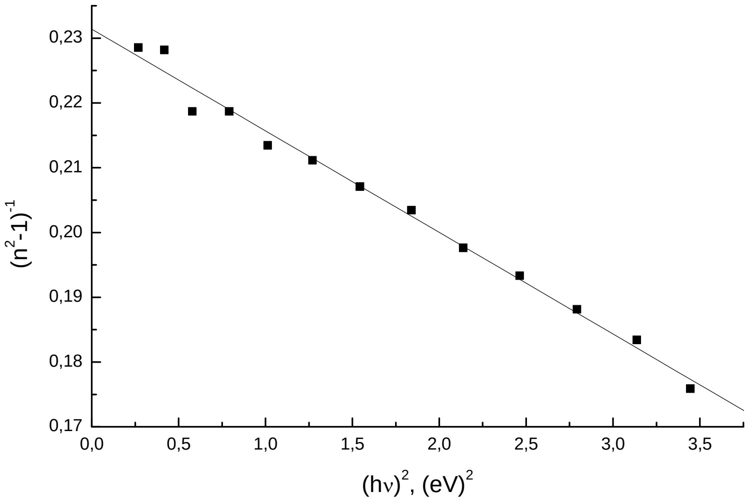

Fig. 1.

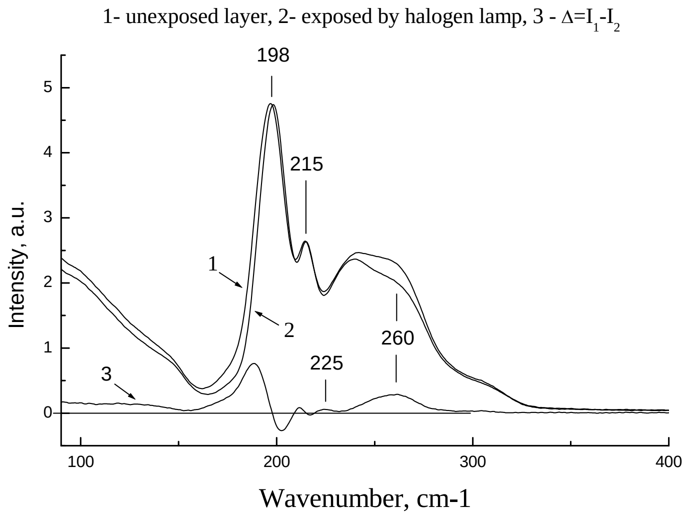

Fig. 2.

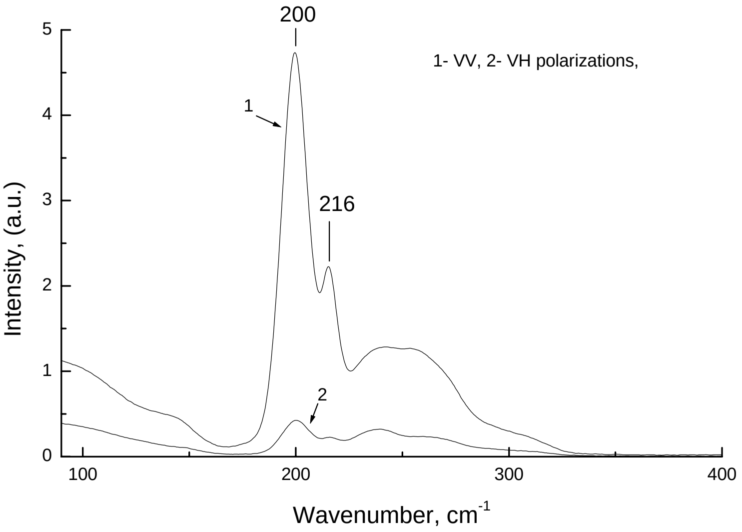

Fig. 3.

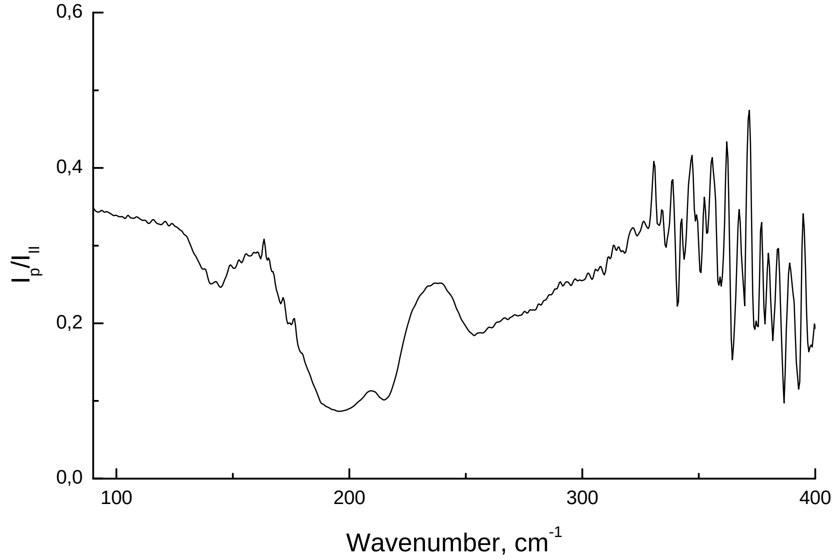

Fig. 4.

In Fig. 2 Raman spectra for $As_{10}Ge_{22.5}Se_{67.5}$ layers are presented for the non-exposed (initial) layers – curve -1 and exposed by halogen lamp radiation – curve 2. The curves are normalized on the intensity of main peak (198 cm^{-1}). In Fig. 3 and 4 Raman spectra for $As_{10}Ge_{22.5}Se_{67.5}$ bulk glass and depolarization spectra, respectively, are shown.

For the Raman spectra of $As - Ge - Se$ glasses the presence of the bands with maxima near 200 and 215 cm^{-1} and wide band 230-280 cm^{-1} is characteristic. During analysis of the Raman spectra of films and glasses it is necessary to take into account the proximity of the masses for As, Ge, Se, which leads to the small differences of the vibration frequencies of the structural units in $As - Ge - Se$ glasses. In the region of glass formation for $As - Ge - Se$ compositions three regions are distinguished – A, B, C [5,6], which differ by main structural units. For A part to which refers and investigated by us composition, the structure of the glasses is described as a mixture of the $AsX_{3/2}$ and $GeX_{4/2}$, connected either directly or through chalcogen chains [5]. For Raman spectra of unexposed $As_{10}Ge_{22.5}Se_{67.5}$ thin layers as well for the glasses the presence of the bands with maxima near 198 and 215 cm^{-1} and wide band 230-280 cm^{-1} is characteristic. Also the band with maximum 305 cm^{-1} can be seen.

After samples exposure the main changes in Raman spectra are in 235-270 cm^{-1} region and also in 160-190 cm^{-1} region. The band with maximum near 198 cm^{-1} corresponds to ν_1 vibrations, and band near 262 cm^{-1} to ν_3 vibrations of the $GeX_{4/2}$ tetrahedric structural units, 215 cm^{-1} band to the vibrations of the end Se atoms in these structural units [5,7]. In the region of wide 230-280 cm^{-1} band are present the vibration frequencies of $AsSe_{3/2}$ pyramidal structural units – 230 cm^{-1}, S_8 - 250 cm^{-1} and S_n chains ~235 cm^{-1} , in this region also are present the frequencies of the enriched by As structural units. The change under the influence of exposure of Raman bands intensity in this region shows the presence of the polymerization processes. It results in the decrease of the number of As-enriched structural units and also S_8 and S_n chains.

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