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STUDY OF OPTICAL, ELECTROPHOTOGRAPHIC AND HOLOGRAPHIC PARAMETERS OF As-Se CONDENSATES FROM THE PREHISTORY OF THE ORIGINAL BULK MATERIALS

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The results of a study of the optical, electrophotographic and holographic parameters of As-Se condensates from the prehistory of the original bulk materials are presented. It has been established that the electrophotographic parameters of freshly deposited $As_{40}Se_{60}$ layers change significantly with temperature; the dependences of the maximum charging potential (U_0) and the half-decay time of the potential ($\tau_{1/2}$) of electrophotographic $As_{40}Se_{60}$ layers in the dark on the processing temperature of the melt of the starting material are shown. The dependence of the half-life of the potential in the dark, as well as the properties of bulk samples, has an extremum in the region of T_{sub}~500°C. The correlation between the dependences of the properties of bulk samples and the electrophotographic parameters of the layers on T_{sub} indicates that the structural features of the source material in the deposition mode used affect the structure of the films.

Keywords: *Chalcogenide glassy glasses; As-Se systems; Charging potential; Potential half-time; Diffraction efficiency; Optical transmittance*

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INTRODUCTION

Currently, the development of modern science and technology in the world, which requires a significant increase in the volume of recording, storage and processing of information, necessitates the development and improvement of recording methods based on the use of various information media [1-5]. Promising materials for these purposes are chalcogenide glassy semiconductors (CHGS) [6-9].

Due to their high photoelectric sensitivity and low electrical conductivity, layers of glassy arsenic chalcogenides have found wide application in electrophotography, photothermoplastic recording of information, and also as active elements of transmitting television tubes – vidicons [10,11].

Factors that currently hinder the widespread use of chalcogenide glassy semiconductors in optical information recording devices are the limited methods for controlling the properties of these materials and their condensates, as well as the insufficiently high reproducibility of their properties. In this regard, an urgent task is to determine the influence of external influences on the structure of glassy arsenic chalcogenides and to develop methods for controlling their properties.

It is known that there is a relationship between the structure of bulk materials and the composition of vapor during their evaporation. We present the results of a study of the dependence of the properties of condensates on the prehistory of the initial bulk materials, carried out on materials of As-Se systems that are of practical importance for types of recording optical information.

EXPERIMENTAL PART

To determine the diffraction efficiency of holograms recorded on As - Se samples , an optical setup was used, the diagram of which is shown in Fig. 1. The recorded holograms were the interference of two flat beams. Angle of convergence ≅ 30°. The radiation source was an LG-38 He-Ne laser.

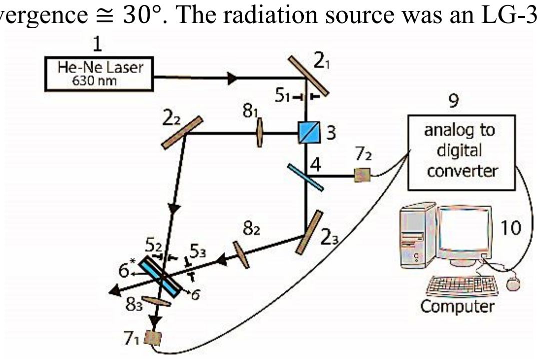

Figure 1. Experimental scheme for studying the holographic characteristics of CHGS films: 1-laser; 2_1, 2_2, 2_3-flat mirrors; 3-cubic prism; 4-translucent plate; 5_1, 5_2-diaphragm mask; 6-sample, 6*-substrate; 7_1, 7_2-registering devices; 8_1, 8_2, 8_3-shutters

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The laser beam (Fig. 1) (1) is divided on a cubic prism (5) into two beams, which are then converged on the surface of the sample (6). The hologram obtained in this way is a diffraction grating, the frequency of the lines of which depends on the installation parameters and can be adjusted. For our case, υ=1000 lines/mm. To obtain maximum contrast of the stripes, a filter (5_1) was introduced that aligns the beams in intensity. Masks (5_2 , 5_3) serve to reduce errors associated with the inhomogeneity of the laser beam and inaccuracy of adjustment. Photosensors and associated recording devices (8_1 , 8_2 , 8_3) serve to measure the diffraction efficiency η, of the sample transparency coefficient T and the energy characteristics of the recording. The recording device is calibrated taking into account the diaphragmatic effect of the masks (5_1 , 5_2, 5_3). The diffraction efficiency was assessed by the ratio of the radiation power of the reference beam, diffracted to the 1st order when reconstructing holograms, to the radiation power of the reference beam itself.

RESULTS AND DISCUSSION

Depending on the processing temperature of bulk CHGS, the microhardness of these materials, the ratio of the height of the crystallization peak to its width, the heat of crystallization, and the type of kinetic curves of differential solubility change [12,14]. As a rule, the dependences of the properties of $As_{40}Se_{60}$ CHGS on the melt processing temperature are of an extreme nature with the extremum located in the region of T_{smp}~500°C, and the critical temperature of the melt, up to which structural modification is effective, for this material under the processing modes in this work is ~550÷600°C. To study the influence of the prehistory of bulk $As_{40}Se_{60}$ samples on the electrophotographic characteristics of their condensates, film samples (from bulk materials with different melt processing temperatures) were sawed onto aluminum substrates at T_{sub}=70 and 150°C. The condensation rate was chosen to be 3 μm/min (T_{smp}~380÷400 °C), since it is known that the electrophotographic properties of $As_{40}Se_{60}$ layers at rates of 3÷6 μm/min do not depend on the condensation rate.

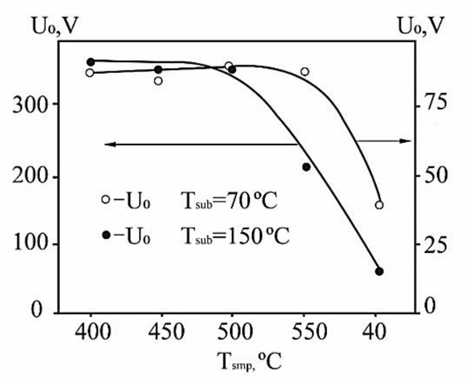

Figure 2. Dependence of the maximum charging potential U_0 of $As_{40}Se_{60}$ layers on the processing temperature of the melt of the starting material

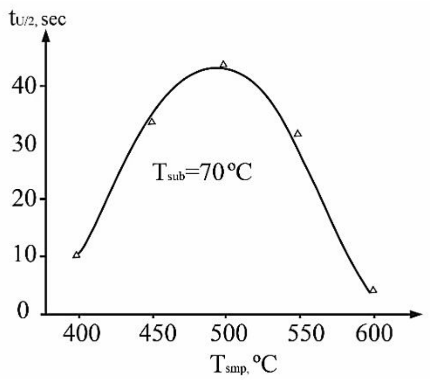

Figure 3. Dependence of the potential half-life in the dark ($t_{u/2}$) of $As_{40}Se_{60}$ layers on the processing temperature of the melt of the starting material

In the course of research, it was established that the electrophotographic parameters of freshly deposited $As_{40}Se_{60}$ layers change significantly with T_{smp}. In Fig. 2. The dependences of the maximum charging potential (U_0) and in Fig. 3. the half-decay time of the potential ($\tau_{1/2}$) of electrophotographic layers of $As_{40}Se_{60}$ in the dark on the processing temperature of the melt of the starting material are presented. The dependence of the half-life of the potential in the dark, as well as the properties of bulk samples, has an extremum in the region of T_{smp}~ 500°C. The correlation between the dependences of the properties of bulk samples and the electrophotographic parameters of the layers on T_{smp} indicates that the structural features of the source material in the deposition mode used affect the structure of the films. The form of these dependencies changes when the condensation conditions change, however, their connection with the prehistory of the source materials is preserved. As can be seen from Fig. 2. the electrophotographic parameters of the layers obtained by condensation onto a substrate heated to 70 °C deteriorate with an increase in the volumetric material Tab above 500°C (there is a decrease in the specific charging potential and its half-life in the dark). An increase in T_{sub} to 150 °C leads to an increase in the absolute values of U_0 and a slight shift of the entire curve to the region of higher processing temperatures.

Since the dark discharge of positively charged electrophotographic layers is caused by the generation of current carriers in the volume of the layer [13], the rate of potential decay in the dark (and, consequently, the half-life) will depend on the degree of structural disorder of the material, on the type and concentration of defects in him.

$As_{40}Se_{60}$ is characterized by the presence of various types of structural defects, such as pairs with variable valence formed on arsenic and selenium atoms, quasi-molecular defects and homopolar As-As, Se-Se bonds. The results of the differential solubility of bulk samples in a 10% KOH solution indicate different concentrations of defects such as "wrong bonds" in samples with different histories, which, as a rule, decreases with increasing T_{sub}. At the same time, with an increase in T_{sub}, the concentration of a pair with a variable valence in the melt increases exponentially and, under certain quenching conditions, is retained in the glass. A more complex situation occurs in the case of temperature dependence of the concentration of quasi-molecular defects. The implementation of different ratios between the concentrations of the listed types of defects contributes to the formation of different thermodynamic properties in materials of the same chemical composition and, as a consequence, the formation of condensates (under identical conditions for their production) with different properties, using samples from different batches as an example. Obviously, in the case of film samples the situation is more complicated compared to bulk materials, since the evaporation process itself, being a powerful effect on the structure of the material, in some cases can lead to "erasing" of the prehistory. However, the conducted studies indicate a significant dependence of some parameters of condensates on the processing temperature of the source material under evaporation modes adopted in the production of devices [13,14].

The study of the effect of heat treatment of bulk materials on the optical and holographic parameters of $As_{40}Se_{60}$ condensates [15] was carried out on film samples with a thickness of 0,3 μm to 1 μm. Sputtering was carried out at $T_{sub} \sim 400°C$ in a vacuum of no worse than 10^{-5} Torr on unheated glass substrates 1 mm thick. Freshly deposited films were irradiated with a He-Ne laser (λ=0,63 μm) until maximum darkening. Transmission spectra were taken from irradiated and unirradiated areas in the wavelength range (0,3+1) μm. In the same interval, the spectra of the annealed samples were taken. To determine the diffraction efficiency of holograms recorded on $As_{40}Se_{60}$ samples, an optical setup was used, the diagram of which is shown in Fig. 1. The diffraction efficiency was assessed by the ratio of the radiation power of the reference beam, diffracted to the 1st order when reconstructing holograms, to the radiation power of the reference beam itself. The determined relative values of the diffraction efficiency η and the shift of the optical transmission edge Δλ in the 1st recording cycle are shown in Fig. 4. The spread of their values is obviously due to some heterogeneity of film thicknesses.

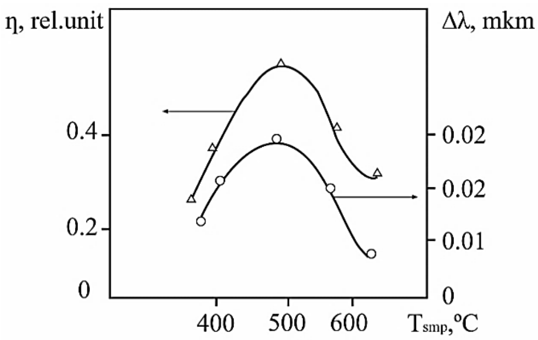

Figure 4. Changes in absorption edge (Δλ) of $As_{40}Se_{60}$ films obtained from bulk materials with diffraction efficiency (η) and shift of the optical different histories

CONCLUSION

Thus, the experimental results obtained indicate a significant influence of the prehistory of bulk materials both on the absolute values of the parameters of their condensates and on the degree of change in these parameters in the process of external influences. This gives grounds to assume a more complex dependence of the function U(R). Metastable states are known that correspond to the structure of a freshly deposited, annealed, irradiated film with quanta of various energies (electrons, optical and X-rays). In addition, each structural state of a film obtained from a bulk material with a certain history obviously corresponds to a certain metastable state and the corresponding minimum of the potential function U(R). The smooth nature of the change in the properties of materials, determined by their prehistory, can be explained by assuming the complex nature of the structure of the very minimum of the function U(R), in particular, the presence in it of a number of shallower potential wells.

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ДОСЛІДЖЕННЯ ОПТИЧНИХ, ЕЛЕКТРОФОТОГРАФІЧНИХ І ГОЛОГРАФІЧНИХ ПАРАМЕТРІВ КОНДЕНСАТІВ As-Se ВІД ПЕРЕДІСТОРІЇ ВИХІДНИХ ОБ'ЄМНИХ МАТЕРІАЛІВ

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Наведено результати дослідження оптичних, електрофотографічних та голографічних параметрів конденсатів As-Se від передісторії вихідних об'ємних матеріалів. Встановлено, що електрофотографічні параметри свіжонапилених шарів $As_{40}Se_{60}$ істотно змінюються з $T_{обр}$, наведено залежності граничного потенціалу зарядки (U_0) і часу спаду потенціалу ($\tau_{1/2}$) електрофотографічних шарів $As_{40}Se_{60}$ в темряві від температури обробки розплаву вихідного матеріалу. Залежність часу спаду потенціалу в темряві, як і властивості об'ємних зразків, має екстремум в області $T_{обр}$~500°C. Кореляція між залежностями властивостей об'ємних зразків та електрофотографічними параметрами шарів від $T_{обр}$ про те, що структурні особливості вихідного матеріалу при використаному режимі напилення впливають на структуру плівок.

Ключові слова: *халькогенідне склоподібне скло; системи As-Se; зарядний потенціал; напівчас спаду потенціалу; дифракційна ефективність; оптичний коефіцієнт пропускання*