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SEMICONDUCTOR CHALCOGENIDE FILMS FOR RECORDING HOLOGRAPHIC INFORMATION.

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ПОЛУПРОВОДНИКОВОЕ МАТЕРИАЛОВЕДЕНИЕ

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Abstract.*The possibilities of using chalcogenide glassy semiconductor films of the system AsSe for recording holographic information are considered. A chart of the results of a study of diffraction efficiency as a function of exposure time is given.*

Keywords: *chalcogenides, hologram, diffraction efficiency, chalcogenide glassy semiconductors (CGS).*

The development of modern computing technology is associated with the creation of an all-optical computer in which both information recording and reading, and information processing is carried out using optical radiation. In this regard, holographic methods of storing and processing information are promising. When creating a holographic memory, an important problem is the choice of a suitable recording material.

Registration of holograms can be realized on a number of substances in which various physical processes occur when interacting with laser radiation. The possibilities of using the following materials are most intensively studied: amorphous semiconductors, thermoplastic materials, magnetic films, vanadium oxides, photochromic materials, ferroelectric photoconductors, and others.

The registration environment must meet a number of requirements:

a) Ensure the identity between the object and its reconstructed image, both in terms of registration and recovery.

b) Have a maximum coefficient (KDP) and minimum energy consumption when recording and restoring an image, i.e. low energy recording threshold;

c) High diffraction efficiency, determined by that part of the reference (reading) beam, which is diffracted for image reconstruction.

d) High resolution;

e) The ability to reuse materials for repeated cycles: write-read-erase, without significant deterioration in the quality of the stored information (material reversibility).

f) Long duration of information storage in memory (storage device) with power off.

Chalcogenide glassy semiconductors can be considered promising materials for recording information in real time. Such materials allow re-recording of optical information after erasing the exposed portion of the film by the initial heating.

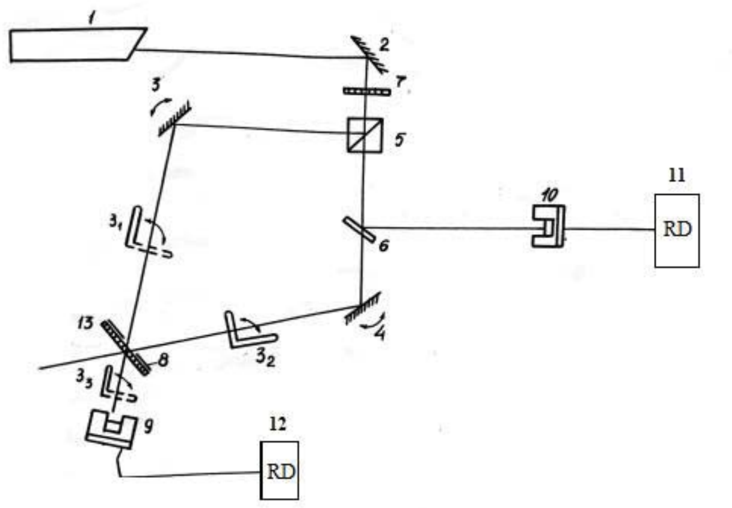

Fig. 1. Experimental scheme for studying the holographic characteristics of chalcogenide glassy semiconductors materials. I-laser LG-38, 2,3,4-flat mirrors, 5-cubic prism, 6-semitransparent plate, 7, 8-apertures, Z1, Z2, Z3-shutters, 9,10-photosensors, 11, 12- recording devices, 13- recording material

Chalcogenide semiconductor glasses include compounds containing one or more chalcogenes (S, Se, Te). In our laboratory, holographic recording was performed using a standard two-beam scheme. (fig. 1)

The laser beam (1) is divided by a cubic prism (5) into two beams, which are then converged on the sample surface (18). The hologram obtained in this way is a diffraction grating, the groove frequency of which depends on the setup parameters and can be adjusted.

For our case, in order to obtain the maximum contrast of the fringes, a filter (9) was introduced to level the beams in intensity. The mask (8) is used to reduce errors associated with laser beam inhomogeneity and inaccuracy of alignment. Photosensors (12,13) and associated potentiometers (14,15) are used to measure the diffraction efficiency of the transparency coefficient of the sample T and the energy characteristics of the record. The potentiometer (P14) is calibrated taking into account the diaphragm effect of the mask (8). The units operate in three modes: 1. Hologram recording mode: shutters G_1 and G_2 are open, G_3 is closed. 2. Diffraction efficiency measurement mode: gate G_1 is closed, gates G_2 and G_3 are open. 3. Mode of measuring the transparency coefficient of the sample: shutter G_1 and G_3 are open, G_2 the gate is closed. In the measurement modes, a 20-fold attenuating filter 7 was introduced. Thus, elementary holograms (diffraction gratings) of Fresnel were recorded on the films, and their diffraction efficiency was measured during the recording.

We selected samples with the highest maximum diffraction efficiency. They turned out to be $As_{50}Se_{50}$; $As_{65}Se_{35}$ and $As_{60}Se_{40}$. As well as for other carriers suitable for holographic recording, it is of interest to determine the dependence of the diffraction efficiency of gratings on exposure.

During the experiment, it was found that with an increase in the intensity of the recording beams, the exposure times corresponding to the attainment of the maxima of the diffraction efficiency decrease in proportion to the increase in the intensities. Taking into account the law of interchangeability, the recording of holograms on all samples was carried out at the same intensity of the recording beams, and the value of the intensity was chosen in the region of stable laser operation. This made it possible to draw certain conclusions when comparing the sensitivity of samples for chalcogenide glassy semiconductors films of different composition, prepared in different laboratories.

Sample $As_{65}Se_{35}$ was exposed much longer to achieve the same diffraction efficiency that was observed for $As_{50}Se_{50}$ although the film thickness $As_{65}Se_{35}$is 7 times less than the film thickness $As_{50}Se_{50}$ (fig. 2).

The same picture is observed when examining samples $As_{65}Se_{35}$ and $As_{60}Se_{40}$.

The shortest exposure time was observed for the $As_{50}Se_{50}$ film, while the highest maximum diffraction efficiency was observed for the $As_{60}Se_{40}$film. Thinner samples have a higher As content, which increases the absorption, and it is known that the sensitivity increases with the increase in absorption. Nevertheless, the “thicker” samples in our studies had a higher sensitivity, based on the exposure dependences of the diffraction efficiency. Losses in the diffraction efficiency may arise due to the nonlinearity of the optical characteristics of materials, which leads to a redistribution of the radiation power to higher orders.

The recorded holograms were erased at a temperature of 160°±3°. The erasure time was chosen so that complete erasure was not visually observed. After annealing, the films were partially destroyed. No damage was observed in the exposed areas. The layer is "photo-ordered"; its strengthening, due to which its thermal destruction in exposed areas is less than in unexposed ones.

It should be noted that the $As_{65}Se_{35}$film has the smallest thickness of all samples. The annealing time for films with a large thickness is shorter than for films with a thinner thickness.

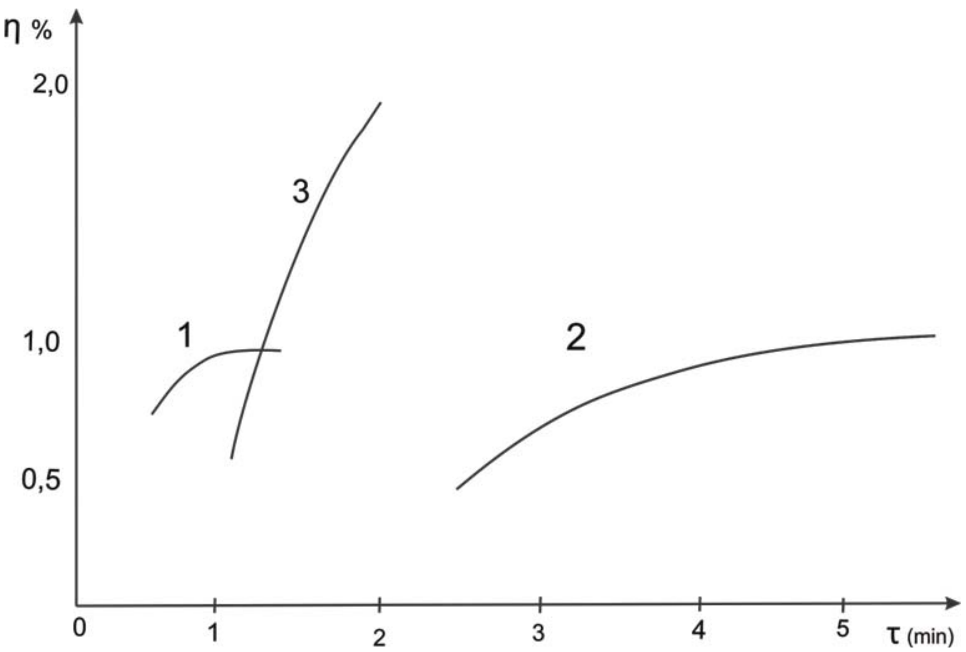

Fig.2 Dependence of diffraction efficiency on exposure time 1. $As_{50}Se_{50}$ 2. $As_{65}Se_{35}$ 3. $As_{60}Se_{40}$

After erasing, not only a drop in the relative transmittance and diffraction efficiency was observed, which is in good agreement with the literature data [1-5], but also, as a rule, an increase in the exposure time to achieve the maximum diffraction efficiency. After heat treatment, the sensitivity value drops.

When recording holograms after erasure, the maximum value of the diffraction efficiency of the samples fell to a greater extent than the relative transmission. Therefore, it can be assumed that the phase component of the recorded holograms undergoes the greatest change during annealing. The change in the diffraction efficiency for $As_{60}Se_{40}$ occurred to a lesser extent than for $As_{50}Se_{50}$, which cannot be said about optimal transmission. The opposite picture is observed here. The degree of change in the diffraction efficiency depends on the preparation method and the composition of the films. The degree of change in the diffraction efficiency depends on the preparation method and the composition of the films. It should be noted that the samples $As_{65}Se_{35}$ and $As_{50}Se_{50}$ have the best reversibility, and the most sensitive one has the best.

Thus, to obtain a good reversibility of information recording, it is necessary to find the optimal composition of the chalcogenide glassy semiconductors and the optimal mode of information erasure, and to prevent cracking of the film, it is desirable to use sapphire substrates, whose linear expansion coefficient is close to the chalcogenide glassy semiconductors coefficient.

It can be concluded that chalcogenide glassy semiconductors is a promising material for the creation of holographic systems for storing and processing information.

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