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Optical recording on surface and inside As_2S_3 thin films

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Chalcogenide semiconductor films are the classic object for investigation of holographic recording. Nevertheless optical recording usually is (carried out) on a surface of film without the focusing of a laser beam. Recording method of micro-hologramms on the surface and in the depth (volume) of film layer is interesting for the practical use. It can considerably increase a total informational capacity of recording and storage medium. For this purpose it is necessary to investigate a possibility of optical recording in two and more layers of definite chalcogenide film, in principle. In the present work optical recording was carried out on As_2Se_3 films by confocal microscope LEICA TCS SP5 at the wavelength 514 and 488 nm. Laser beam was focused up to diametre 0.6 μm on the surface of film and 4-8 μm inside the film respectively. Recording was made by scanning film area from 16 to 64 μm^2. The readout was performed at wavelength 633 nm by measuring reflection and transmission before and after recording. The readout was done by scanning film along recording area and its thickness. The results display that reflected signal at recording on the surface and in the depth of film differs in the order of magnitude. Possibility of recording in the As_2Se_3 films at different wevelengths enable to optimize the ratio of reflected signals at the recording on surface and in the volume of film.

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Keywords: Amorphous chalcogenide films, Confocal microscope, Optical recording

1. Introduction

Chalcogenide semiconductor films are a classical object of investigations for holographic recording [1-5]. However, holographic recording usually is carried out on the surface of the film or in the whole thickness of the film depending on the depth of the penetration of laser radiation. The so-called “dot-matrix” method of recording is interesting for practical use when the laser beam is focused to 10 – 30 μm diameter dot in which hologram is recorded [6]. To increase a capacity of the information storage material the recording of dot holograms should be performed both on the surface and inside the film. At present this method of non-holographic recording by bit is realized in DVD-s [7]. In the present work we find out that optical recording in the As_2S_3 films by bit can be realized on the surface and in the depth of the film with good resolution of the signals coming from the surface and the depth of film during readout. Since holographic recording with high diffraction efficiency is possible in $A_{S2}S_3$ films, the next step in research will be the implementation of dot holographic recording on the surface and inside of the film.

2. Experimental details

The As_2S_3 films were made by vacuum evaporation on glass substrates previously covered by aluminium. The thickness of films was controlled in the process of evaporating by interference method. For optical recording and readout of the reflected signal confocal microscope TCSP-5 (Leica) with object lens 63 x and digital aperture was used. Optical recording (488 nm and 514 nm) was carried out by scanning of the area 3.84 × 3.84 μm by focused laser beam in diameter 0.5 μm. The exposure energy was from 0.04 J/cm^2 to 0.4 J/cm^2 (Fig. 1).

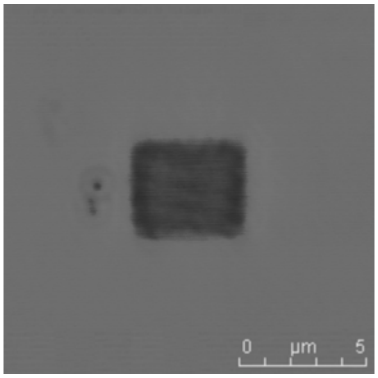

Fig. 1. The surface picture of the As_2S_3 – Al system, obtained by confocal scanning microscope at the wavelength 514 nm. In the centre – optical recording with area 3.84 × 3.84 μm carried out by laser radiation 514 nm at exposure 0.4 J/cm^2.

Before optical recording the scanning of the film by weakened radiation was carried out through the thickness of film measuring reflected signal from the film (Fig. 2). After that the power of radiation was increased and optical recording was carried out (Fig. 1). Then the film was scanned again through the thickness by weakened light. The change of the reflected signal after optical recording testify about photostimulated changes which are happened in the film.

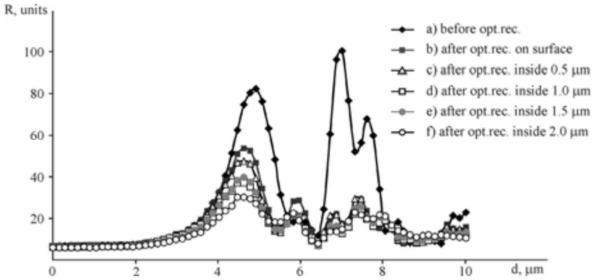

Fig. 2. Dependence of reflected readout signal (λ = 514 nm) on the position of focal plane of the object – lens before optical recording (a) and after recording (λ = 514 nm, I = 0.04 J/cm^2) on the surface (b), in the depth (c, d, e ,f) of the As$_2$S$_3$ film at thickness 2.23 µm.

3. Results and discussion

The dependence of reflected signal from the system As$_2$S$_3$ – Al on the position of the focal plane of the object – lens is represented in Fig 2. Coordinates of the focal plane, where the first maximum is observed, corresponds to the surface of the film. Changing the coordinate of the focal plane it is possible to focus the laser beam both on the surface and the inside of the film. Light influence causes the change of the refraction index of As$_2$S$_3$ film as well as subsequent shift of maximums and the change of their amplitude in comparison with the initial signal (Fig. 2). For the study of the influence of radiation energy on the photostimulated changes, the film with thickness of 2.23 µm was exposure with light of different intensity (the time of irradiation remained constant) with positions focal plane at the distance 0 µm, 0.5 µm, 1 µm, 1.5 µm, 2 µm from the surface of the film inside it. Fig. 3 shows dependence $\Delta R/R_0$ on energy of radiation, where $\Delta R=R_0-R$ – difference between the maximum value of the reflection R_0 from the surface of as-evaporated film and maximum reflection R of irradiated film. It is seen that maximum differences are observed at exposition 0.4 J/cm^2.

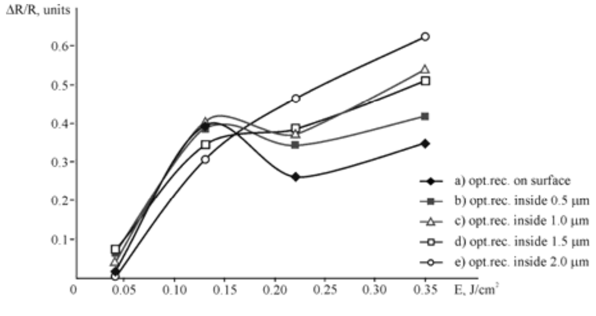

Fig. 3. Dependence of relative change of reflected readout signal (λ = 514 nm) on the energy of radiation (λ = 514 nm) after recording on the surface (a), in the depth (b, c, d, e) of the As$_2$S$_3$ film at thickness 2.23 µm.

Using the wavelength 488 nm for optical recording and readout we did not get differences in the value of reflected signal in the cases of focusing of laser beam on the surface and in the depth of the film (Fig. 4). It may be explained by the fact that radiation with the wavelength of the 488 nm is strongly absorbed by the surface layer, where photoinduced processes take place.

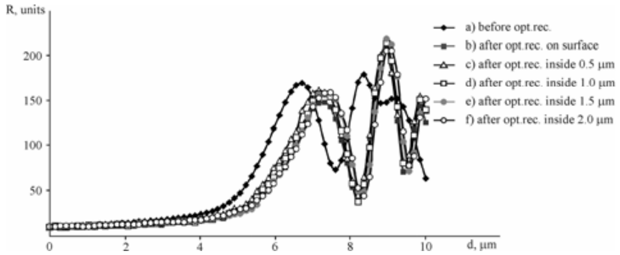

Fig. 4. Dependence of reflected readout signal (λ = 488 nm) on the position of focal plane of the object – lens before optical recording (a) and after recording (λ = 488 nm, I = 0.04 J/cm^2) on the surface (b), in the depth (c,d,e,f) of the As$_2$S$_3$film with thickness 2.23 µm.

Due to this fact we used different wavelengths for recording on the surface (488 nm) and inside the film (514 nm). Fig. 5 shows the dependence of reflected readout signal at the wavelength 514 nm on the position of focal plane of object – lens; after carrying out optical recording inside the film (b), on the surface and inside the film one above the other (c), on the surface (d).

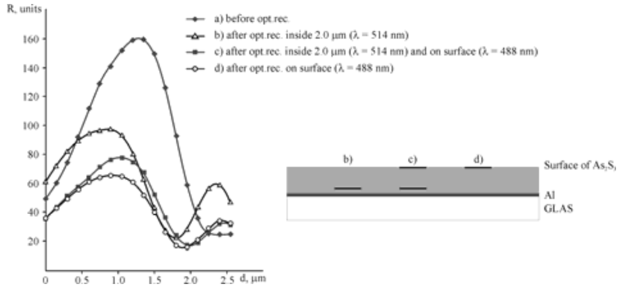

Fig. 5. Dependence of reflected readout signal (λ = 514 nm) on the position of focal plane of the object – lens before the optical recording (a) and after recording (λ = 514 nm, I = 0.13 J/cm^2) in the depth (b), recording in the depth (λ = 514 nm, I = 0.13 J/cm^2) and on the surface (λ = 488 nm, I = 0.13 J/cm^2) (d) of the As$_2$S$_3$ film with thickness 2.23 µm.

Recording inside and on the surface of film was carried out at the wavelength 514 nm and 488 nm respectively. An essential difference in signals allows to determine whether the recording was carried out on the surface or in the inner layers of the film.

4. Conclusions

The possibility of optical recording in the system As$_2$S$_3$ – A1 on the surface and in the inner layers of the film is shown.

The difference in the values of the readout signal allows to determine whether the recording was carried out on the surface or inside the film.

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