Laser-induced anisotropic absorbtion, reflection and scattering of ligth in chalcogenide glassy semiconductors

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Anisotropy induced in thin–film and bulk samples of chalcogenide glassy semiconductors by the linearly polarized light of different spectral ranges is studied. Three different ranges of exciting photons energy can be distinguished. 1) Above-band-gap light excitation is studied in film samples, two distinct processes are identified in this range: creation of photoinduced defects and their photostimulated orientation and reorientation; a "defects based" model of photoinduced anisotropy is further developed. 2) Sub-band-gap light excitation is studied in bulk samples; creation of anisotropically scattering centers is assumed to be the basis of all photoinduced vectorial phenomena in that spectral range. 3) Super-band-gap light excitation is studied in both film and bulk samples due to application of differential reflectance spectroscopy; it was shown that not only defects but also main covalent bonds of the glass can be oriented and reoriented by the linearly polarized light generating the photoinduced dichroism in this spectral interval.

1. Introduction

It is honor for us to write a paper for the special issue of *Physics and Technics of Semiconductors* in recognition of the outstanding role of our teacher, Professor Boris Timofeevich Kolomiets, to the field of disordered semiconductors. We want to stress that Professor Kolomiets was not only the pioneer in the broad study of glassy semiconductors but directly participated in the initial investigation of photoinduced anisotropy in these materials.

The phenomenon of photoinduced anisotropy (PA) was discovered when we studied the polarization state of light transmitted through the film of calcogenide glassy semiconductor (ChGS), irradiated by the linearly polarized laser beam [1,2]. Both photoinduced dichroism and photoinduced birefringence of absorption, observed in the experiments, were explained by interaction of light with optically anisotropic structural elements whose optical axes are oriented randomly [2]. Later, these phenomena were investigated by different authors, working with ChGS films of various compositions [3–8]. Different approaches to explain PA were developed that are based on consideration of interaction of the inducing light with native quasiatomic defects [7], with quasimolecular defects (three-center bonds) [9] or with bistable centers having a wide distribution of relaxation times [10]. Fritzsche discussed the photoinduced redistribution of anisotropic microvolumes as a base of PA [11], and Tikhomirov and Elliott developed recently a new model [8], in which the PA is connected with photostimulated orientation and reorientation of valence-alteration pairs (VAP's) that are characteristic defects in chalcogenide glasses [12]. All above-mentioned effects were obtained at investigation of thin ChGS films irradiated by above-band-gap light.

Phenomena of photoinduced dichroism were revealed also in bulk ChGS (As_2S_3 and $As_{34}S_{52}I_{14}$ bulk glasses) [13,14] and in As_2S_3 chalcogenide glassy fibers irradiated by the sub-band-gap light [15]. Later, investigation of PA in bulk ChGS samples was carried out by many research groups [16,17].

In this paper we consider the results of the PA study accomplished recently in the amorphous semiconductors laboratory of the Ben-Gurion University (Beer-Sheva, Israel) either independently or in close cooperation with colleagues from other research centers.

It is convenient to divide all data obtained into parts concerning the photoinduced anisotropic absorbtion, reflection and scattering of light. We will consider additionally the cases of polarization-dependent laser-induced crystallization of some amorphous chalcogenide films and of polarization-dependent photodoping of ChGS films with silver.

2. Experimental

Two groups of samples were investigated in this research. Thin-film samples were produced by thermal evaporation of starting glassy meterials onto silica glass substrates in vacuum under residual pressure $p \sim 10^{-6}$ Torr. The film thickness was $0.3 \div 4.0\,\mu$m. Bulk samples were prepared by polishing melt-quenched chalcogenide glasses and had typical thickness of several milimeters.

All measurements were done at room temperature using the experimental installations schematically shown in Fig. 1. The set-up of Fig. 1, *a* was used for investigation of thin film samples. Two beams of identical gas lasers (either He–Ne-lasers, working at $\lambda = 633$ nm or Ar^+-lasers, working at $\lambda = 515$ nm) illuminated simultaneously the same area of the film studied. The linear polarization state of one laser (inducing light) could be changed to the orthogonal one with a quarter wave plate. The attenuated light beam from the other laser (probing light) passed through an electrooptical modulator, which modulated the polarization discontinuously between two orthogonal states at a frequency of 1 kHz. Then this laser beam passed through the sample and was incident on the Si photodiode (PD), permitting to measure the photoinduced transmission anisotropy $T_{II} - T_I = 2(I_{II} - I_I)/(I_{II} + I_I)$, where I_{II} and I_I

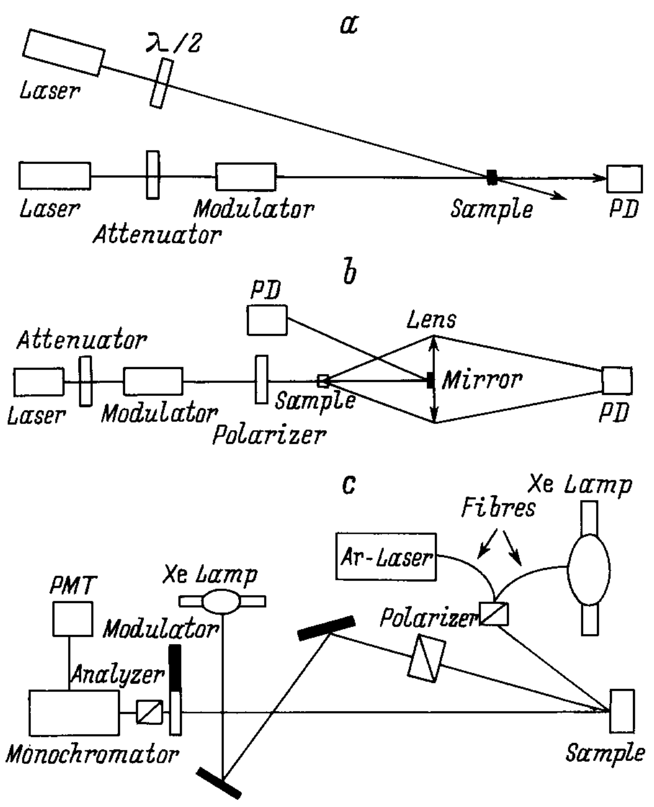

Figure 1. Experimental installations for investigation of photoinduced anisotropy of absorbtion (*a*), scattering (*b*) and reflection (*c*) of laser light.

are the intensities of the beams with two orthogonal electric vectors. This set-up permitted to study very initial periods of PA kinetcs and relaxation. To measure the difference signal $I_{II} - I_I$ we used the method of synchronous detection.

In Fig. 1, *b* the installation is shown that allowed to measure simultaneously the laser radiation transmitted through the bulk ChGS sample and radiation scattered by the sample to various angles up to 230 mrad. Collecting lens, arranged behind the sample, focused the scattered ligth to a photodiode, and a small mirror, fixed in the central part of the lens, reflected the transmitted light beam to a second photodiode. He–Ne-laser radiation ($\lambda = 633$ nm) which was sub-band-gap radiation for the studied bulk glass samples (As_2S_3 glass) played in this installation, by turns, a role of inducing or probing light.

The experimental set-up for reflectance difference measurements is shows in Fig. 1, *c*. It is again the two-beams installation. The anisotropy in this case was induced using the light of either a 1000 W Xenon lamp equipped with an IR-cutoff filter which generated radiation in a wide energy range, including sub-band-gap and super-band-gap light, or an Ar^+-laser ($\lambda = 488$ nm) generating above-band-gap light for the studied samples. The inducing light passed through a Glan-prism polarizer and besides the light intensity on the surface of the sample was around 100 mW/cm^2. The intensity of the measuring linearly polarized light, generated by small Xenon lamp, was much smaller (about 5 mW/cm^2) and did not induce any noticeable change in the anisotropy during the measurements. Application of a monochromator allowed to investigate the spectra of PA of light reflection. For a detailed acquaintance with the reflection-difference spectroscopy see [18].

3. Results and discussion

3.1. Anisotropic light absoption

In our recent research [19,20] we obtained the data which permit further development of Tikhomirov anf Elliott's model [8]. We used the installation shown in Fig. 1, *a*. Studying the AsSe films, we demonstrated that the whole process of dichroism generation in the case of above-band-gap light excitation can be divided into two subprocesses. The first process is the generation of some centers that can be oriented by the polarized light and the second one is the photostimulated orientation (and reorientation) of these centers.

The process of photoinduced dichroism appearance and reorientation in the AsSe film of 1.2 μm thickness at 2.75 W/cm^2 light intensity is illustrated in Fig. 2. It is seen from Fig. 2, *a* that the initial dichroism generation is rather prolonged ($10 \div 20$ min), while the dichroism reorientation happens much quicker (< 1 min). Quick reorientation was observed not only after dichroism saturation, as it is shown in Fig. 2, *a*, but also in the initial moments of dichroism growth. Moreover, in the case of long film irradiation with the non-polarized light, the following irradiation with linearly polarized light results in the rapid appearance of dichroism as it is shown in Fig. 2, *b*.

When the dichroism generation and reorientation in the same AsSe film was excited by the action of linearly polarized light of different intensities, the dichroism reorientation always occurs much quicker than the initial dichroism growth, although at smaller light intensity both initial dichroism generation and is reorientation are more prolonged than at higher light intensity. Important that in all these cases the dichroism achieves approximately the same value. Similar peculiarities in the kinetics of dichroism generation and reorientation were observed also in amorphous $As_{45}Se_{55}$, As_2S_3 and Ge_2PbS_4 films. So, Fig. 2, *c* demonstrates different kinetics of dichroism generation and reorientation in the As_2S_3 film. We want to stress that a division into slow dichroism appearance and quick dichroism reorientation is especially dictinct in the films of certain thicknesses and at certain values of exciting light intensity.

Fig. 3 shows the room-temperature kinetics of repeated photoinduced dichroism (*D*) generation after heating the film to a certain temperature, keeping it at this temperature and then cooling to room temperature. The kinetics of room-temperature dichroism reorientation in the non-annealed films is also shown. It is seen that the gradual increase of annealing temperature brings the form of the dichroism growing curve nearer to that in the virgin film, and practically

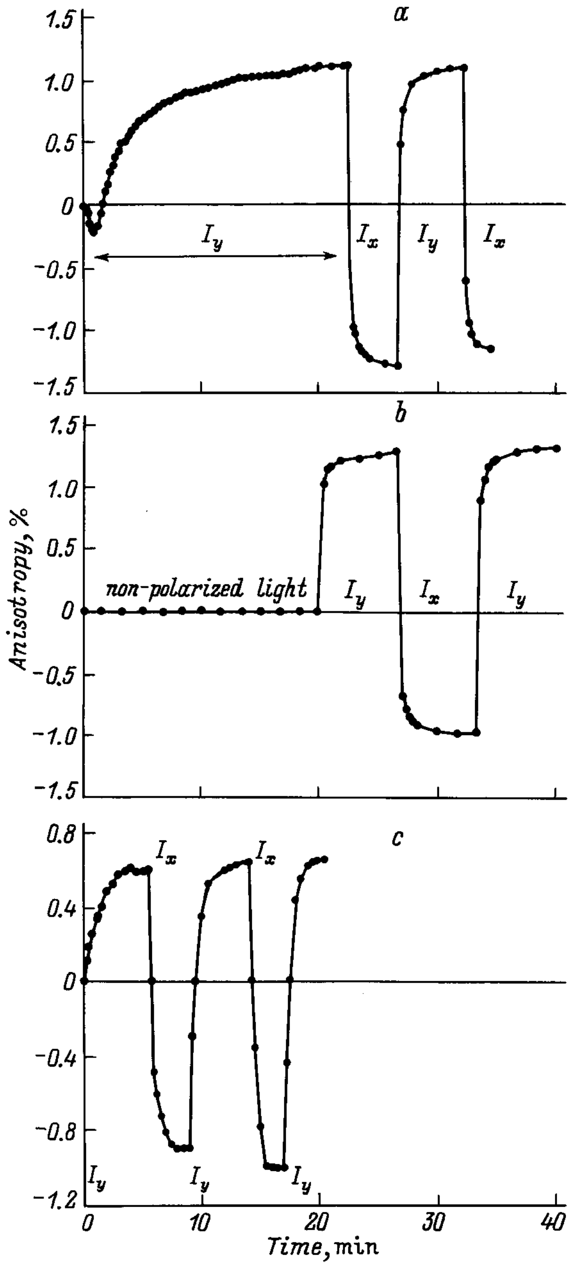

Figure 2. Kinetics of dichroism generation and reorientation in AsSe (a, b) and As_2S_3 (c) films under action of linearly polarized laser light with two orthogonal directions of electrical vector (y and x), when reorientation starts after dichroism saturation (a, c) or polarized light irradiation starts after long illumination with non-polarized light (b).

perfect identity of the curves has place after annealing at 180°C temperature that is the softening temperature of the AsSe film. We want to remind that the total bleaching of photodarkened AsSe film was also observed at temperature close to the softening temperature, while the partial bleaching starts at lower temperatures [21].

All above–described results show that irradiation with both polarized and non-polarized above-band-gap light creates some centers in the non-irradiated film that can be oriented quickly by the subsequent irradiation with linearly polarized light (in case of initial irradiation with the polarized light, these centers are oriented during this irradiation). The constant dichroism saturation value at different light intensities testifies to the limited number of centers that can be oriented. The results of the heating experiments allow to think that the same centers (or, may be, some part of these centers that are capable to be oriented) are responsible for both the photodarkening and saturated value of PA. These centers can be born in the form of VAP's in the reactions [12]:

$$2\,C_2^0 + h\nu \rightarrow C_1^- + C_3^+ \quad \text{and} \quad C_2^0 + P_3^0 + h\nu \rightarrow C_1^- + P_4^+, \qquad (1)$$

where C and P mean the chalcogen and pnictide atoms.

Uniting the ideas proposed in [18] and [11], we assume that the polarized light initiates reactions

$$C_1^- + C_3^+ + h\nu \rightarrow C_1^+ + C_3^-$$

and

$$C_1^- + P_4^+ + h\nu \rightarrow C_1^+ + P_4^-, \qquad (2)$$

and these reactions occur much more often in the VAP's with dipole moment orieted in parallel to electrical vector of exciting light. Afterwards, the energetically advantageous reactions

$$C_1^+ + C_3^- \rightarrow C_1^- + C_3^+ \quad \text{and} \quad C_1^+ + P_4^- \rightarrow C_1^- + P_4^+ \qquad (3)$$

take place, but now the $C_1^- + C_3^+$ and $C_1^- + P_4^+$ defects are oriented randomly. The whole process is accompanied by the decrease of the number of VAP's having the dipole moments co-directed with the electrical vector of the inducing light and by the growth of anisotropy that we have observed.

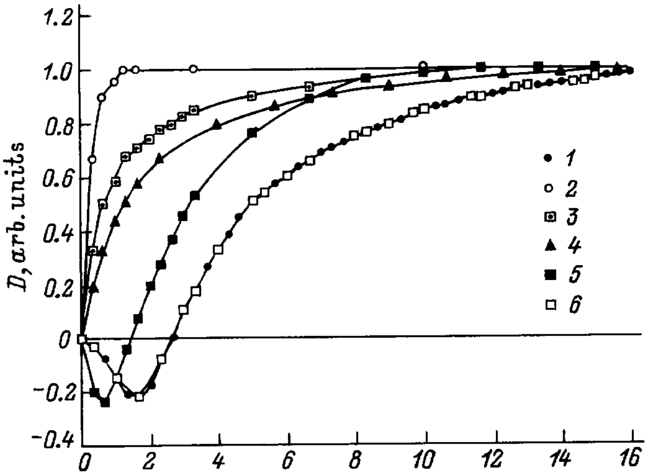

Figure 3. Kinetics of room temperature dichroism (D) generation in virgin AsSe film of 1.2 μm thickness (*1*), repeated dichroism generation after annealing at 75 (*3*), 95 (*4*), 140 (*5*), 180°C (*6*) and kinetics of one cycle of room temperature dichroism reorientation in such film (*2*). Intensity of linearly polarized He–Ne-laser light is 2.75 W/cm^2.

3.2. Anisotropic light scattering

The photoinduced light scattering in bulk ChGS, excited by the sub-band-gap light was revealed for the first time in [14]. This effect was displayed as a change of the shape of the transmitted laser beam, as an appearance of speckled structure and as a photoinduced modification of trace of the laser beam inside the irradiated ChGS bulk sample. Semiquantitative data confirming the light scattering were also obtained [14].

In this research we investigated carefully the photoinduced light scattering in bulk As_2S_3 glass and first of all, the anisotropy of light scattering. The obtained results allowed to propose some new ideas about the mechanism of the whole group of vectorial photoinduced phenomena in bulk ChGS [22].

We used the set-up shown in Fig. 1, *b*. The He–Ne-laser light ($h\nu = 1.96\,\mathrm{eV}$, $W = 10\,\mathrm{mW}$) which was a sub-band-gap radiation for an As_2S_3 glass ($E_g = 2.3\,\mathrm{eV}$) has been used in these experiments carried out at the room temperature. Study of the angular distribution of the intesity of probing light transmitted through the sample (using a special movable diaphragm) before and after its irradiation with an exciting light beam permitted to consider the light at the angles up to 5 mrad as a directly transmitted light and the light at larger angles as a scattered light.

We studied the kinetics of change of scattered light intensity induced by strong linearly polarized radiation with two orthogonal directions of electrical vector ($\mathbf{E}_y$-radiation and $\mathbf{E}_x$-radiation). It was shown that the $\mathbf{E}_y$-radiation, for example, induces an increase of scattering of the corresponding light (I_y). Simultaneously, the intensity of I_x light usually decreases. On the contrany, the $\mathbf{E}_x$-radiation induces a decrease of I_y-light and a growth of I_x-light.

Fig. 4 shows a typical kinetics of photoinduced changes of the scattered light anisotropy $2(I_{sy}-I_{sx})/(I_{sy}+I_{sx})$ and of the transmitted light anisotropy $2(I_{ty}-I_{tx})/(I_{ty}+I_{tx})$, connected with the values of scattering dichroism β_s, absorption dichroism β and the sample thickness h by the simple relations:

$$2(I_{sy} - I_{sx})/(I_{sy} + I_{sx}) = \beta_s h,$$

$$2(I_{ty} - I_{tx})/(I_{ty} + I_{tx}) = \beta h.$$

It is seen from the figure that scattering anisotropy and transmittance anosotropy always change in opposite directions: an increase of one of them is accompanied by the decrease of the other one and vice versa. The anisotropy of scattering and transmittance were shown to remain practically invariant during at least $3 \div 5$ hours. It is concluded from the data of Fig. 4 that it is possible to reorientate the PA.

In some experiments the sample was first excited by non-polarized light ($\mathbf{E}_y + \mathbf{E}_x$) and only then was irradiated by linearly polarized radiation. Non-polarized radiation induced additional isotropic light scattering, while the subsequent linearly polarized radiation led to the appearance of scattering anisotropy, and this anisotropy could be reoriented.

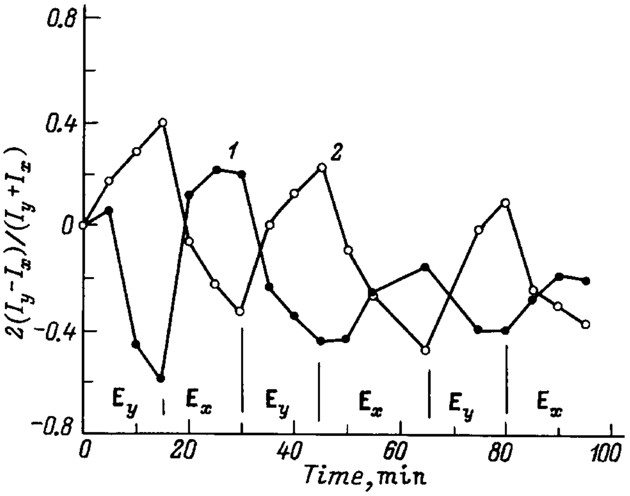

Figure 4. Kinetics of transmittance anisotropy (*1*) and scattering anisotropy (*2*) changes in an As_2S_3 bulk glass sample induced by $\mathbf{E}_y$- and $\mathbf{E}_x$-laser radiation.

Obtained quantitative data on the photo-induced light scattering anisotropy permit us to draw some interesting conclusions. The opposite directed changes of photoinduced anisotropy of transmittance and scattering allow us to assume that the creation of anisotropically scattering centers is the basis of the whole group of photoinduced vectorial phenomena in ChGS. This hypothesis makes understandable the fact that anisotropy is excited by the sub-band-gap light. The energy of corresponding light quanta is not enough to break the interatomic covalent bond, but enough to produce some changes in the system of weaker bonds, for example, intermolecular Van der Waals bonds or the so-called three-center bonds [9]. These changes can result in the appearance of scattering centers in the glass. We can assume that only a finite number of scattering centers can be created by the inducing radiation. Such centers will scatter the light either isotropically or anisotropically, depending on the polarization state of the inducing radiation. The anisotropy of such centers can be reoriented when the polarization state of the inducing radiation is changed. The different states of scattering centers (*x*-oriented, *y*-oriented, isotropic) reflect the possibility of certain structural fragments in the glass to exist in several quasi-stable states as was considered in the case of photodarkening in ChGS [21].

3.3. Anistropic light reflection

All previous studies of PA in ChGS used the transmittance measurements and for this reason only the effect of sub-band-gap and above-band-gap light was investigated. Interaction of ChGS with the photons having the energy substantially exceeding the optical gap of ChGS could not be studied because of strong absorbtion. Below we report the results of the reflectance-difference spectroscopy application which allowed us to investigate the photoinduced anisotropy in ChGS in a broad spectral range [23]. We obtained in this research many new results, particularly, we demonstrated that anisotropy can be excited by photons with energy substantially exceeding the band-gap of the ChGS and found, that PA can be detected at energies much higher than the energy of photons in the exciting radiation.

We worked with installation shown in Fig. 1,*c* and investigated both thin films and bulk samples of As_2S_3, AsSe and $Ge_{20}As_{20}S_{60}$ chalcogenide glasses. The measured value is defined as $\Delta r/r = 2(r_{II} - r_I)/(r_{II} + r_I)$, where r_{II} and r_I are the reflectance values for the polarization of the probing beam in the direction parallel or perpendicular to the polarization of the inducing beam.

In all thin films and bulk glassy samples studied we recorded PA in the whole investigated spectral range ($1.5 \div 5.0$ eV), while the non-irradiated samples were either completely optically isotropic or showed very slight anisotropy due to preparation conditions. On changing the exciting light polarization to orthogonal, the reflectance curve indicated a change in the anisotropy sign.

Fig. 5 shows the PA of light reflection in the bulk As_2S_3 induced by the linearly polarized light of Xe-lamp or Ar^+-laser. It is seen that the anisotropy is appeared in the whole $1.5 \div 5.0$ eV range. Interesting that for the glass excited by Xe-lamp light the trend in the reflectance change was the same (increase or decrease depending on the polarization) throughout the whole studied spectral range. At the same time, in case of the Ar^+-laser excitation, sign variation of the effect is clearly recorded. The increase in $\Delta r/r$ is observed for larger photon energies (above 4.0 eV) similar to the previous case of polychromatic light excitation but for smaller photon energies an opposite change (decrease)is detected. It is seen also that a change of the light polarization to the orthogonal one results in a reversal of the PA with the same crossover energy of 4.0 eV.

We demonstrated also that the anisotropy of reflection is induced faster and to a larger magnitude if the studied sample was preirradiated for $2 \div 3$ hours by the non-polarized full light of the 1000 W Xe-lamp. All peculiarities of PA of reflection were shown to be characteristic not only for As_2S_3 glass but also for all ChGS studied.

The possibility to observe PA at energies much larger than the exciting photon energy indicates that by irradiation of ChGS with linearly polarized light not only defects or the scattering centers can be oriented and reoriented by light but also the main covalent network of the glass becomes anisotropic, it means that the main interatomic covalent bonds can be also oriented and reoriented.

The data on the anisotropy of reflection induced by the sub-band-gap and above-band-gap light can be understood in close analogy with the explanation given in parts 3.1 and 3.2. The most interesting results which must be explained are the data on the difference of reflection spectra for the cases of Xe-lamp and Ar^+-laser light excitation (Figs. 5,*a* and 5,*b*). One of the posibilities to understand this difference is demonstrated in Fig. 5,*c* for the simplest case of elemental amorphous selenium. In the initial state, atom *3* is threefold coordinated and atom *10* is onefold coordinated. Following the photoexcitation by the light with polarization shown in the figure, lone-pair (LP) electrons oriented parallel to this orientation will predominantly be excited. As a result, atom *10* may form a covalent bond with a neighbouring atom *8*, making the latter threefold coordinated. To keep the defect concentration and charge balance, initial threefold coordinated atom *3* decays into a singly coordinated defect

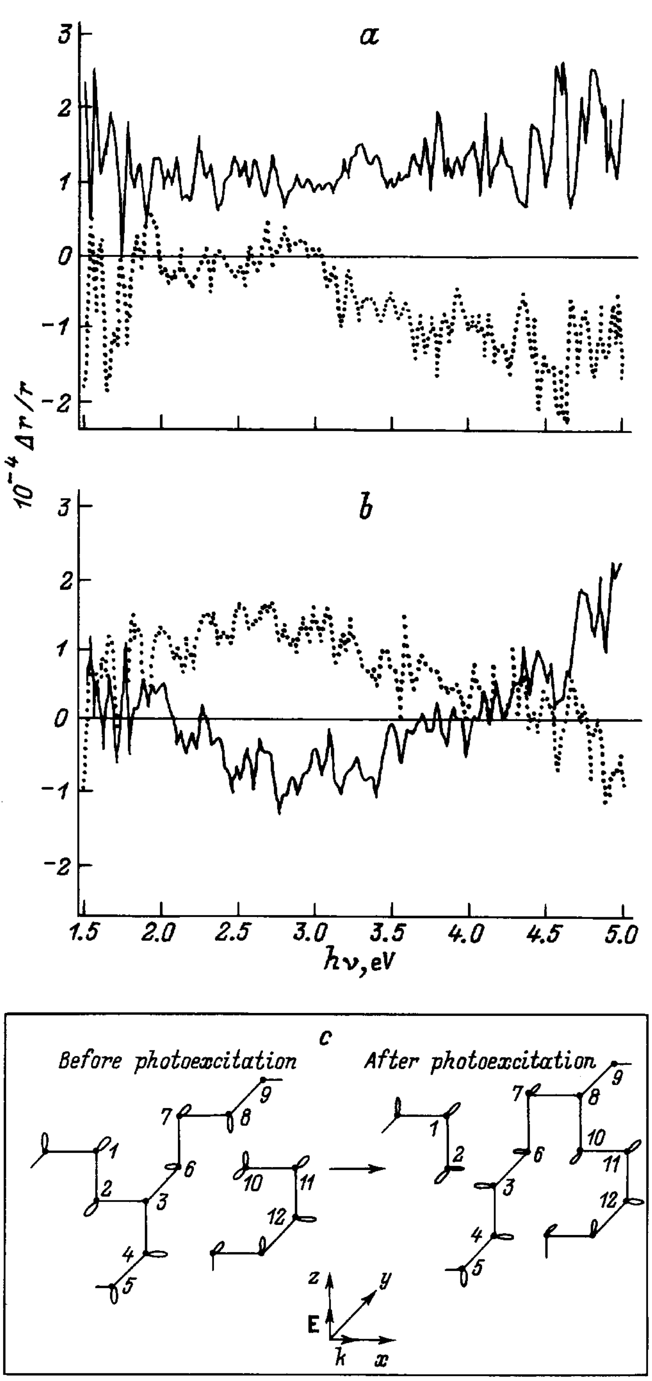

Figure 5. Photoinduced reflectance anisotropy (solid line) and its reorientation (dotted line) in an As_2S_3 bulk glass sample irradiated by the light of 1000 W Xe-lamp (*a*) or Ar^+-laser (*2*) and schematic representation of photostructural changes induced by the above-band-gap light (*c*).

and a twofold coordinated "regular" atom. We see here a redistribution of LP and bonding orbitals. Before photoexcitation the bond between atoms *2* and *3* was covalent (parallel to the x axis), while atoms *8* and *10* had LP orbitals parallel to the z axis. After the photoexcitation, atoms *8* and *10* became bonded by a covalent bond in the z direction, while the bond between atoms *2* and *3* is broken, and two LP orbitals parallel to the x axis are created. As a result, the total number of bonding electrons along the z axis decreases, while the number of non-bonding electrons along the x axis increases, which explains the opposite change in the anisotropy probed at lower and higher energies. In other words, conversion between bonding and non-bonding electrons proceeds. Both natural and photoinduced defects can participate in this process and this is clearly evidenced from the comparison of the kinetics of PA of reflection in the non-irradiated samples and in the samples preirradiated by the non-polarized light.

In the case of broad-spectrum light (Xe-lamp), the above-considered process still exists but, additionally, the direct excitation of bonding electrons by the high-energy light quanta becomes possible, resulting in the decrease in the number of bonding electrons in the direction of the light polarization. Since the density of states is larger for bonding electrons than for LP electrons, this latter process will overcompensate a decrease in the number of covalent bonds caused by the excitation with the sub-band-gap light, leading to the same change in the sign of anisotropy for both lower and higher energies.

3.4. Polarization-dependent laser-induced anisotropic crystallization of some ChGS films

Laser-induced anisotropic absorbtion of light, considered in part 3.1, was observed in various ChGS films irradiated by the above-band-gap linearly polarized light, but in some thermally treated Se–Ag–I films and in films of elemental amorphous selenium we observed very unusual kinetics of linear dichroism generation and reorientation [24]. As in the other cases, in that films the dichroism was generated slowly under the action of linearly polarized light, and a change of the polarization vector to the orthogonal one resulted in the reorientation of dichroism, but unlike the previously studied cases, the constant change of reorientation kinetics was observed and then the alteration of the dichroism sign was recorded (Fig. 6, *a*). If at the beginning of the experiment, the vertical polarization vector stimulated increase of positive dichroism, while the horizontal polarization vector diminished positive dichroism and excited negative dichroism, in the following stages the reverse processes were observed.

The photoinduced dichroism excited by the He–Ne-laser light at a constant direction of polarization vector changed the sign very soon and grew slowly, achieving very large values of about 15 ÷ 18% as it is shown in Fig. 6, *b*. The sign of the final dichroism always was determined by the direction of the exciting light polarization vector. The dichroism induced by irradiation of the same Se–Ag–I film with an Ar^+-laser light displayed similar dependence but the saturated dichroism value was essentially lower and was achieved quicker. Some relaxation of dichroism with time after cessation of irradiation was characteristic for the early periods and was not observed in the final stages of dichroism generation. Annealing of irradiated films at glass transition

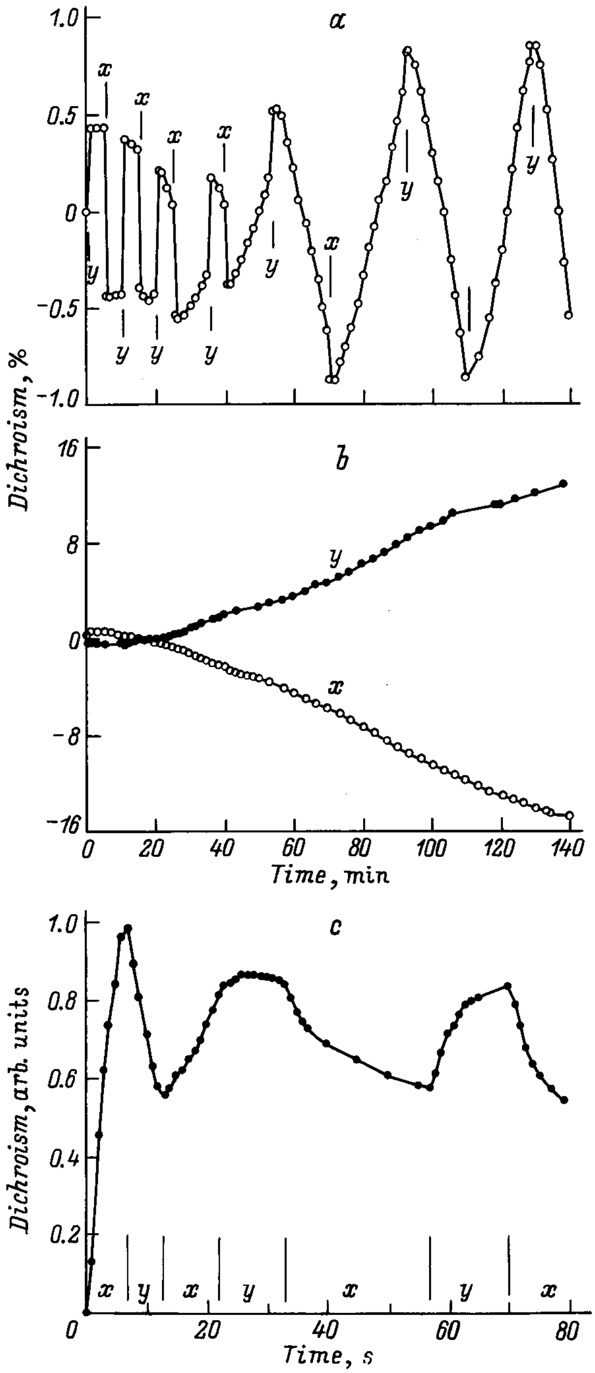

Figure 6. Kinetics of dichroism generation and reorientation in a treated $\mathrm{Se}_{70}\mathrm{Ag}_{15}\mathrm{I}_{15}$ film (a, b) and in AsSe film photodoped with silver (c) induced by a linearly polarized He–Ne-laser beam when generation and reorientation cycles are carried out by horizontal (x) and vertical (y) directions of the electrical vector.

temperature (55°C) and at $80 \div 90$°C for several hours did not lead to a destruction of photoinduced dichroism opposite to the situation in the AsSe films.

Thus, all characteristics of PA in treated Se–Ag–I and *a*-Se films were different from those in films studied previously. The results obtained (unusual kinetics, another sign and large value of photoinduced dichroism, absence of relaxation and thermal destruction) permitted us to assume that we deal with photoinduced photocrystallization process [25–27].

This assumption was confirmed by the direct structural investigation including optical microscopy, electron microscopy and X-ray diffraction study. Initially more or less homogeneous films with an uniform morfology indicate distinctly crystallization after irradiation. X-ray analysis of irradiated Se–Ag–I films showed the presence of Se, Ag_2Se and AgI microcrystals. Difference in the kinetics and the saturated values of photoinduced dichroism excited by He–Ne and Ar^+ laser beams is explained by different values of light penetration depths connected with different absorbtion coefficients of red and green light. Thus, we observed for the first time the polarization-dependent laser-induced anisotropic photocrystallization of Se–Ag–I and *a*-Se films. At the same time, investigating the structure of the samples by all the above-mentioned methods, we did not observe any preferential orientation of the crystallites in the photocrystallized films.

3.5. Polarization-dependent photodoping of chalcogenide glassy films with silver

ChGs films are known to be photodoped with silver and other metals with following drastical changes in the optical, electrical and physico–chemical properties (see review articles [28,29]). It was shown also that the silver photodoping of As_2S_3 glassy films using linearly polarized light is accompanied by generation of strong dichroism with sign opposite to that generated in Ag-free ChGS films [29]. This phenomenon was called as "polarized photodoping" of ChGS films.

Recently we investigated in details the polarized photodoping in ChGS films of different compositions — As_2S_3, As_2Se_3, AsSe and $GeS_{2.2}$ and observed in all these cases the same peculiarities of this phenomenon as were observed previously at the polarized photodoping of As_2S_3 films. Our attention was attracted to the kinetics of dichroism reorientation. We observed the constant change of reorientation kinetics that was accompanied by a change of the dichroism sign. We realized that in the first cycles of dichroism reorientation, the horizontal polarization vector stimulated increase of positive dichroism, while the vertical polarization vector decreased the dichroism value, in the following stages the reverse picture was recorded as it is shown in Fig. 6, *c* for the of AsSe film photodoped with silver. This situation remined us the picture that we observed in case of above-considered photoinduced polarized crystallization and we decided to investigate the structure of photodoped films. Using optical microscopy, we drew conclusion that the prolonged laser-induced photodoping really leads to partial polarization-dependent photocrystallization of three-component As(Ge)–Se(S)–Ag materials obtained in the process of photodoping.

4. Conclusion

The detailed investigation of interaction of linearly polarized light with ChGS allowes us to conclude that a tendency to photoinduced macro-anisotropy is a common property of these materials. It manifests in ainsotropic light absorbtion, reflection and scattering which can be observed in different spectral ranges using various exterimental techniques. The common base for this photoinduced macro-anisotropy is the existance in ChGS of large number of micro-anisotropic fragments. In the non-irradiated ChGS such fragments are oriented randomly, making the samples optical macro-isotropic (we do not consider here the cases of natural optical anisotropy investigated in [30,31]). Polarized light leads to the redistribution of these fragments. Such general idea was suggested in the very first papers concerning the photoinduced anisotropy in ChGS [1,2]. One of possible cases of such redistribution was considered in detail by Fritzsche [11]. Moreover, our experiments demonstrated that not only natural fragments but also photoinduced fragments (defects) are micro-anisotropic and can be oriented and reoriented by the linearly polarized light.

We are convinced now that the role of such micro-anisotropic fragments in ChGS can play different defects and even interatomic bonds that determine the anisotropy excited by the light of different spectral ranges: sub-band-gap, above-band-gap and super-band-gap light.

We want to mention especially that irradiation with linearly polarized light can result in many unusual and interesting phenomena in ChGS. Examples of such phenomena, polarization-dependent photocrystallization and polarization–dependent Ag-photodoping were considered in this paper.

Acknowledgments

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