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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

SURFACE PROCESSES IN LAYERED GaS AND GaS: Yb MONOCRYSTALS IRRADIATED WITH GAMMA QUANTA

Speciality: 2225.01 – Radiation Materials Science

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GENERAL CHARACTERISTICS OF THE RESEARCH WORK

Relevance of the research topic. One of the problems facing radiation materials science is the development of methods to increase the resistance of materials to radiation. Despite the use of various technological methods for this purpose, there is no unified scientific basis for the management of material properties.

Si, GaAs, etc. materials are widely used in microelectronics, photoelectronic and optoelectronics, and high-conductivity atoms such as Li and C are used as impurity atoms to increase their sustainability against radiation. However, due to concentration of the impurity atoms in the substance depends on its solubility, the concentration of the defects is partially compensated. This does not allow to control durability of materials over a wide radiation range. Therefore, it is required develop new methods for managing properties of materials. One of the methods currently used in the instrument manufacturing industry is radiation technology. This method is used in the manufacture of high-efficiency photodetectors, solar cells and quantum pits. Radiation addition is widely used in the modification of semiconductor materials, especially in the process of purposeful control of the properties Si and GaAs semiconductor materials. Although the applied impurity radiation model is suitable for the processing of these materials, it poses certain obstacles for defective semiconductors with a layered and chain structure. Thus, structural defects in the surface region of layered semiconductors are more complex than volume defects. Since the absorption and desorption properties of surface defects depend on external factors, especially ionizing radiation, temperature and electric field, the study of their joint effect on surface conductivity is of practical and scientific importance. It is known that the control of the sensitivity of photoreceivers, solar cells and photoresistors based on semiconductor materials in the visible and ultraviolet regions of the spectrum is of special importance in the development of optoelectronic systems. However, the fact that the defects play the role of recombination center in the surface area of the materials increases the rate of recombination of the charge carriers. Since the value of the surface recombination rate of charge carriers depends on the structure of the semiconductor material, the interaction among defects and other external factors (radiation, temperature, electromagnetic field), the development of a method of controlling the surface effects in layered and chain crystals can allow the development of new photodevices.

For this reason, GaS monocrystal is selected as the object of study as an active representative of $A^{III}B^{VI}$ compounds. In the GaS monocrystals, the location of the component elements in the layer follows the S-Ga-Ga-S position rule, this rule follows a weak Van der Vaals connection between the layers. For this reason, interlayer bonds in layered crystals, including GaS monocrystals, are anisotropic. Although the electrical, photoelectric and optical properties of GaS monocrystals have been extensively studied, the characteristics of the combined effect of surface and radiation defects on the current-carrying mechanism have not been studied.[1] - indicate that since layered crystals do not have broken atoms in the surface region, these crystals are highly durable to external influences. For this reason, in layered crystals, the surface does not need mechanical and chemical processing, as the atoms in the surface region have an orderly arrangement. However, the analysis of heterostructures based on layered crystals, VAC of Schottky diodes shows that the high diode coefficient (n ~ 2.5-4) is due to the high concentration of surface defects. This causes the sensitivity of the photoreceivers based on these structures to be small in the ultraviolet and visible regions of the spectrum. As shown in, the photosensitivity of photoreceivers based on semiconductor materials in the absorption band depends on the material acquisition technology, surface treatment and morphology [2]. Although these properties and the processes occurring in the surface area of materials have been partially studied in layered monocrystals (InSe, GaSe), GaS and its

[1]Abdullayev H. B. Yarımkeçirici çeviricilər / H.B. Abdullayev, Z.Ə. İsgəndərzadə; - Baki: Elm, - 1974, - 297p.

[2]Zərbəliyev, M.M. Yarımkeçiricilər fizikası / M.M. Zərbəliyev, - Bakı: - Təhsil NPM, -2008, - 455 p.

alloys have not been studied in GaS: Yb monocrystals. GaS monocrystals have a wide band gap (2.5 eV, T = 300 K) and have high photosensitivity in the visible region of the spectrum (0.4 ÷ 0.7 μm). With the introduction of impurity atoms (Er, Yb) it is possible to control its spectrum sensitivity region. As in other layered crystals, the concentration of defects in GaS crystals is $\sim 10^{17}$ cm^{-3}.

Although there are some proposals to modify the photoelectric, electrical and optical properties of crystals by regulating the concentration of defects (temperature, ionizing radiation, electric field, additives, etc.), the scientific basis of the processes has not been fully developed.

Studies have shown that, simple defects caused by γ-rays in the GaS monocrystals interact with structural and additive defects to form neutral complexes. Such complexes, formed in the presence of cation atoms, reduce the conductivity of crystals at low doses of radiation and increase them at high doses of radiation. Since the defects formed during irradiation are evenly distributed throughout the volume of the crystal, their effect on the processes occurring on the surface of the crystal is not taken into account. This, for example, does not allow us to determine the causes of the decrease in the photosensitivity of the crystal in the shortwave region. Therefore, to control the processes occurring in the surface region of layered crystals, it is necessary to take into account the nature of the defects, their interaction with defects caused by additive atoms and other effects, as well as the role of external influences. The creation of a physical mechanism for the occurrence of these processes can help to create new characteristic diode structures based on layered crystals.

The dissertation work was carried out by the scientific research plan of the laboratory of " Radiation Physics of Semiconductors" at the Institute of Radiation Problems of the Azerbaijan National Academy of Sciences.

Aims and purpose of the research:

To determine of the properties of the interaction of radiation defects caused by γ-rays in the surface region of layered GaS and

GaS:Yb monocrystals with structural defects and impurity atoms and the development of methods for processing surface defects.

The following issues have been resolved to achieve to the aim:

- Growth of GaS and GaS: Yb monocrystals, investigation of their crystal structure and determination of lattice parameters;
- Study of the effect of γ-rays and thermal evaporation on the structure and lattice parameters of GaS and GaS: Yb monocrystals;
- Investigation of the effect of the electric field before and after irradiation on the photoconductivity in the absorption band of GaS and GaS: Yb monocrystals;
- Study of interatomic interactions of GaS and GaS:Yb monocrystals in the surface region before and after irradiation, as well as after thermal evaporation by Fourier transform infrared (FTIR) spectrometer.
- Study of the effect of gamma radiation and temperature on the surface morphology of GaS and GaS:Yb monocrystals by Atomic Force Microscopy (AFM).

Research objects and methods:

Objects of research are GaS and GaS:Yb layered monocrystals. During the research process, the method of irradiation of the surface of these compounds with γ-quanta, the study of the interaction of surface defects with radiation defects in GaS and GaS: Yb layered crystals, investigation of surface of layered semiconductor GaS and GaS: Yb monocrystals irradiated with γ-quanta by spectroscopic and microscopic (AFM) methods, methods of influence of γ-quanta on thermo- and photoluminescence properties in GaS and GaS: Yb layered monocrystals were used.

Main provisions to the defence:

1. Characteristics of the effect of surface structure and radiation defects, the external electric field on the photosensitivity observed in the absorption band of GaS monocrystals;

2. Characteristics of the effect of surface structure and radiation defects,the external electric field on the photosensitivity observed in the absorption band of GaS: Yb monocrystals;
3. Determination of the effect of radiation defects and thermal evaporation on the nature of interatomic interactions (surface morphology) of GaS and GaS: Yb monocrystals in the surface region by IR spectroscopy and Atomic Force Microscopy (AFM).

The scientific novelty of the research:

1. A correlation was found between the nature and concentration of surface defects and the photosensitivity observed in the absorption band in purity and impurity GaS monocrystals.
2. The geometric dimensions and periodicity dependence of the radiation dose and the level of impurity of non-smooth conical surfaces with a height of 30 ÷ 40 nm and periodicity of 16 nm in the surface area of the layered GaS monocrystals have been determined.
3. It was found that no changes in specific photoconductivity, absorption band characterizing interlayer and intralayer oscillations are observed in the GaS monocrystals due to the weak interaction between structural and radiation defects at Dγ <50 krad radiation doses.
4. It was found that in GaS and GaS: Yb monocrystals, an increase in the interaction of structural and radiation defects in the radiation dose range of 50 $<D_\gamma<$200 krad, an increase in photosensitivity in the absorption band and a decrease in interlayer oscillations due to redistribution of defects.

The scientific and practical significance of the research:

The scientific significance of the dissertation is, for the first time, the regularities of effect of surface defects on the electrophysical, photoelectric and optical properties been determined in the layered crystals. The results show that there is a correlation between surface effects and physical properties. It can be used for the manufacturing various types of photodetectors, diodes and optoelectronic devices based on layered crystals. Other valuable fact is that the results obtained during the study prove the possibility of radiation-technological processing of the properties of layered crystals, and the obtained results can be used in the manufacture of diode structures.

Approbation and implementation:

The results of the dissertation were presented at the following Republican and International events:

- "II International Scientific Conference of Young Researchers" dedicated to the 91st anniversary of national leader Heydar Aliyev (Baku, Azerbaijan-2014);
- "The Seventh Eurasian Conference Nuclear Science and its Application" (Baku-Azerbaijan, 2014);
- “VIII Republican Conference on Modern Problems of Physics Dedicated to the 95th Anniversary of BSU” (Baku-Azerbaijan);
- “III International Scientific Conference of Young Researchers dedicated to the 92nd anniversary of the national leader of the Azerbaijani people Heydar Aliyev” (Baku, Azerbaijan-2015);
- “Academic Science Week-2015 International Multidisciplinary Forum” (Baku, Azerbaijan-2015)
- XXIII International Conference of Students, Postgraduates and Young Scientists "Lomonosov", Moscow Section "Physics" (Moscow-2016);
- "İnternational Youth forum İntegration Processes of the World Science in the 21st Century" (Ganja Azerbaijan, 2016);
- I International Scientific Conference of Young Researchers dedicated to the 94th anniversary of national leader Heydar Aliyev (Baku, Azerbaijan-2017);
- 11th International Conference "Nuclear and radiation physics", (Almaty, Kazakhstan-2017),
- "The Third Interdisciplinary Youth Scientific Forum with International Participation" New Materials "(Moscow-2017);
- “II international scientific conference of young researchers” (Baku, Azerbaijan-2018) Academician H.B. International

conference and school dedicated to the 100th anniversary of Abdullayev (Baku, Azerbaijan-2018).

Publications: The main materials of the dissertation were published in 25 publications, including 13 articles (including 4 foreign scientific journals with an impact factor) and 12 conference theses. The results were published in the report of the Institute of Radiation Problems of the Azerbaijan National Academy of Sciences.

Name of the organization the Dissertation has been performed:

The dissertation work was carried out in the laboratory "Radiation physics of semiconductors" of the Institute of Radiation Problems of the Azerbaijan National Academy of Sciences.

Volume, structure and main content of the dissertation:

The dissertation consists of an introduction, 4 chapters, results and a list of 141 references. The volume of the work consists of 102 printed pages of text, 17 tables, 28 figures and a total of 234,558 characters.

CONTENT OF WORK

The introduction, the relevance of the topic substantiated and information on research methods, scientific innovation and practical significance of the work, the purpose of the work, the structure and content of the work, the main provisions to be defended and the approbation of the work emphasized.

Chapter I of the dissertation gives brief information about the structure, properties and electrophysical properties of layered semiconductors. At the same time, their different properties from volume crystals have been investigated, and suggestions are made on the areas of application of layered crystals in practice. Taking into account the features mentioned in the chapter, the topic of the dissertation work and the issues were determined based on the results of the radiation technology method applied for the purposeful control of the properties of layered monocrystals.

Chapter II provides information on the technology of growth and the impurity of layered monocrystals. Homogeneous GaS monocrystals were grown by the alloy-directed crystallization method and had p-type conductivity. To reduce the concentration of sulfur vacancies during the growth of GaS monocrystals, sulfur (1.5%) was used more than the stoichiometric ratio. The specific resistance of the samples was $2 \cdot 10^9$ and $3 \cdot 10^7$ Ohm · cm at room temperature in the direction of the axis c and the direction perpendicular to it, respectively. During crystal growth, the concentration of Yb was $N_{Yb} \sim 10^{14}$ cm^{-3}. Silver paste and Indium were used as ohmic contacts in purity and impurity crystals.

Microstructure and X-ray phase analyzes were performed to determine the degree of monocrystalline of the obtained homogeneous monocrystals. Based on the results obtained, the lattice parameters were calculated before and after irradiation and it was determined that the studied monocrystals were homogeneous. Fourier-IR reflection spectrum of the samples were recorded on the FTIR Varian 3600 spectrometer in the frequency range ν = 400-100 cm^{-1}. The excitation spectrums are plotted at an angle of incidence $\varphi = 15^0$.

Microscopic studies of the surface relief of GaS and GaS: Yb samples were performed before and after irradiated by gamma rays under Atomic Force Microscopy (AFM). For this purpose, two-dimensional (2D) and three-dimensional (3D) AFM-images of the surface, as well as histograms in the (üfüqi elə horizontal demekdir burada vertical and horizontal yazmaq istəmisiz yəqinki) horizontal directions (100x100 nm) obtained.

The samples irradiated with gamma rays from a ^{60}Co source at room temperature at a dose rate of dD_γ/dt = 15.66 rad/s. The radiation dose of the samples was 30, 50, 100, 140 and 200 krad, while the absorbed dose was D_γ = 30-200 krad.

Chapter III presents the results of the study of the photoconductivity observed in the absorption band of purity and impurity GaS: Yb monocrystals over a wide radiation dose and temperature range. It is known that the modification of gamma radiation and additive atoms of layered crystals causes changes in their electrical, photoelectric and optical properties and some surface effects, which in turn affect the course of volumetric processes. Since the study of the effect of these processes on the photoconductivity of crystals in the visible and ultraviolet regions of the spectrum is of practical and scientific importance, the object of study was selected as an purity and impurity GaS crystal.

Initially, the effect of an external electric field on the photoconductivity in the absorption band of an purity GaS monocrystals was studied at different temperatures. It was found that the low photosensitivity in the short-wavelength region of the spectrum is because of the high concentration of defects (~10^{17} cm^{-3}) in the superficial region. Defects observed in the surface region are natural complexes with cation vacancies and uncontrolled additive atoms ($V_{Ga}X_i$). Because these types of defects act as recombination centres for photo charge carriers, they cause a decrease in photosensitivity in the short-wavelength region of the spectrum (0.4-0.6μm). The GaS monocrystal studied to control the load state of surface defects was placed in an external electric field (between loaded planes) and its value and direction were controlled by the voltage applied to the plates. The value of the external area was 10^3-10^4V/cm. It was found that the photosensitivity increases in the absorption band in the positive direction of the external field ($U_n > 0$), but decreases when the external field is $U_n < 0$. Considering structure of the energy band to clarify the mechanism of the effect, is it possible to claim:

a) is located in the maximum specific absorption band observed in the spectrum of photoconductivity at the value of energy hν ~ 2.52 eV and is associated with the zonal transition of electrons;

b) Transformation of the photoconductivity spectrum in the absorption band of the external electric field in the purity and impurity GaS: Yb crystals is associated with a change in the rate of transfer of charge carriers to the recombination centres.

To determine the relationship between the observed effect and surface defects, photoconductivity spectrum were studied under the influence of an external electric field after irradiation of GaS and GaS: Yb crystals with γ-rays at different doses.

The effect of the external electric field on the photoconductivity spectrum observed in the absorption band is also observed in GaS samples irradiated with γ-rays (Fig. 1). As can be seen from the figure, when Ung> 0 in samples irradiated with γ-rays at a dose of D_γ <50 krad, the photosensitivity in the absorption region increases by 30 – 40 % (Fig. 1, curve 2) compared to the original sample (curve 1). It should be noted that after irradiation at a dose (D_γ > 50 krad), the photoconductivity of the GaS crystal decreases in the whole region of the spectrum. Additional maximum intensity in the spectrum at 2.62eV decreases by increasing radiation dose and is not observed at d > 200 krad doses (Fig. 1 curve 1,2,3). This fact indicates that the level is of the donor type and the degree of compensation increases depending on the radiation dose.

Figure 2 shows the spectral dependence of the photoconductivity of irradiated GaS samples when the electric field is $U_n < 0$. Note that in all the initial samples studied, the FC maximum (piki sekilde qeyd etmisinizse ele FK olaraq qalmalidir)is observed near λ_{max} = 490 nm. As can be seen from the figure, when $U_n < 0$ is the electric field, the FC decreases in the entire spectral range. When irradiated with γ-rays at a dose of D_γ = 50 krad, the state of the specific maximum and the shape of the spectrum in the photoconductivity spectrum remain the same as Un> 0, while the photocurrent is significantly reduced (curve 2). Subsequently, the photosensitivity of the samples decreases as a result of radiation, which is associated with an increase in the concentration of recombination centres in the studied samples (Figure 2).

A comparison of the results shows that, when the external electric field is $U_n < 0$, the photosensitivity observed in the absorption band of the samples decreases exponentially with increasing radiation dose, and increases when $U_n > 0$. The non-monotonous dependence of the observed FC signal on the value and direction of the electric field allows us to assume the relationship of the GaS layered crystal with the real spectrum of surface conditions.

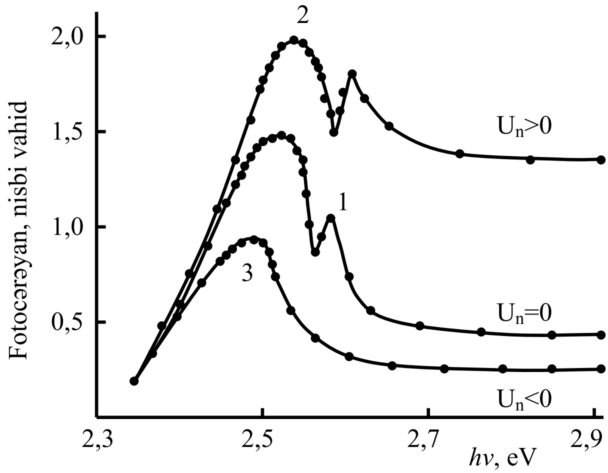

Figure 1. Spectral distribution of photoconductivity in GaS layered crystal at different voltages (T = 77 K): 1 - U_n = 0; 2 - U_n > 0; 3 - U_n <0.

At the same time, the effect of the impurity atoms on the photoconductivity of GaS monocrystals observed in the absorption band in the external field was studied. Figure 3 shows the photoconductivity spectrum of GaS:Yb samples before and after radiation in an external electric field (T = 100 K). As can be seen from the figure, in the p-GaS:Yb crystal sample, the photosensitivity increases when $U_n > 0$, and decreases significantly when $U_n < 0$, which is due to the redistribution of the charged defects under the influence of the electric field. Any characteristic changes in the photoconductivity spectrum as a result of the effect of an external electric field are not observed after irradiation of the p-GaS: Yb crystal with γ-ray. The figure shows that in p-GaS:Yb samples, the state of the specific maximum in the photoconductivity spectrums during irradiation with γ-ray at a dose of 50 krad remains the same as in crystals before irradiation, but increases in the value of the photocurrent when Un > 0 (curve 1). Subsequently, as the radiation dose increases, the photocurrent in the samples decreases significantly, which is associated with an increase in the concentration of recombination centres (curve 2).

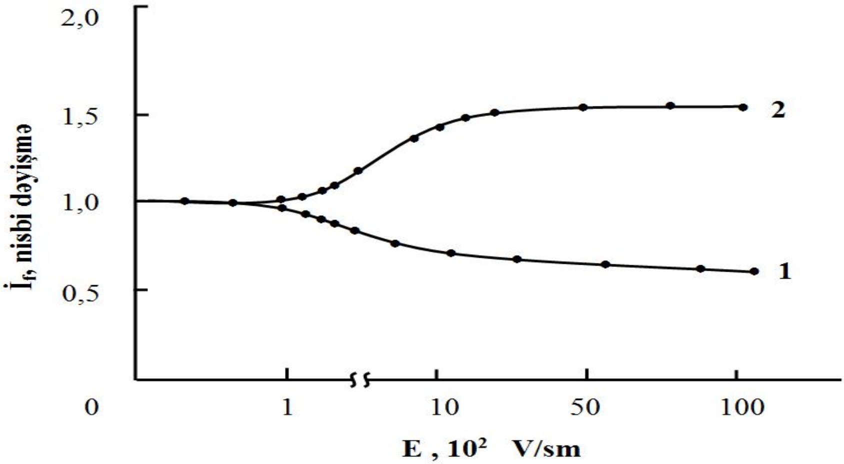

Figure 2. Dependence of the photocurrent on the intensity of the electric field between the electrodes in the specific absorption region ($h\nu_{max}$ = 2.5 eV) in the GaS monocrystals: 1. $U_n < 0$ 2.$U_n > 0$ (d = 0.1 mm; U ~ 1 ÷ 100V)

1. No increase in photoconductivity is observed when $E_{out}<10^2$ V/cm.

2. Change of photoconductivity are observed when $E_{out}> 10^2$ V/cm.

Based on our research, it can be said that cation and anion-type defects occur in the surface region during the extraction of layered crystals of $A^{III}B^{VI}$ type, including p-GaS crystals. Due to their local distribution in the surface area, the anisotropy of conductivity is observed in these crystals. One of the factors that strongly affect the photoconductivity spectrum in the absorption band is the local heterogeneous electric field. According to the experimental results obtained, the electric field on the surface of the crystal varies with the direction of the transverse electric field and the value of the voltage. By changing the value and sign of the transverse field, the photosensitivity can be controlled in layered crystals at low temperatures. Based on the obtained results, it is possible to control the degree of compensation of cation-type defects existing in the surface area as a result of the impurity of layered materials, as well as their irradiation with γ-rays. Observation of this effect can increase the photoconductivity in the visible region of the spectrum in layered crystals, based on which the development of high-sensitivity and γ-ray-resistant photoreceivers.

During the study of the photoelectric properties of GaS monocrystal, it was found that the presence of different types of capture and recombination centres in the forbidden zone leads to the transformation of the spectrum.

Thus, the effect of an external electric field on the photoconductivity in GaS and GaS: Yb crystals is related to the change of the rate of charge carriers transfer to the recombination centres. Accordingly, the main factor in the formation of the effect of an external electric field on the photoconductivity spectrum of layered crystals is the surface electric field generated by the localization of surface charge carriers.

The study of thermoluminescence (TL) spectrum may be a suitable method for studying trap levels present in the forbidden zone of GaS and GaS: Yb crystals. It is known that trap levels have a significant effect on the duration of luminescence, as trap levels capture charge carriers, prevent them from recombination to luminescence centres, and delay luminescence. The depth of the traps is determined by knowing the temperatures corresponding to the maximums of the TL-curves.

During the heating of the crystal, intense maximums are observed in the thermoluminescence curves at different temperatures. When the crystal is heated, the electrons get enough energy to escape from traps, and escaped electrons return to the centre of luminescence and recombinate again. At deep traps, peaks in the TL spectrum are observed at different temperatures, as shown in Figures 1 and 2. The reason is, electrons need more energy to escape from deep traps. As can be seen in Figures 1 and 2, several maximums are observed in the TL spectrum. This indicates that the traps are distributed throughout different depths in the forbidden zone and each maximum corresponds to one trap level.

In Chapter IV have been investigated surface changes as a result of the effect of gamma radiation ($D\gamma$ = 30-200 krad) and thermal evaporation (T=100-250^{0}C) in GaS and GaS: Yb layered crystals by the Fourier-IR, Fourier-Raman spectroscopy and AFM-microscopy methods. For this purpose, the dependence of the intra- and interlayer oscillations of the Raman peaks, the spectral parameters of the transverse (TO) and longitudinal (LO) IR-reflection bands (maximum of frequencies, intensities and half-width) of the samples on the absorption dose and thermal infusion were determined.

It was found that no change in the surface was observed at the radiation dose values $D_\gamma < 50$ krad (Fig.3). However, the surface modification occurs at values of gamma radiation absorption dose of $50 < D_\gamma \leq 200$ krad, which corresponds to the width and length of the Raman peaks (ν = 23.2 and 188.4 cm^{-1}) and the transverse interlayer $E_{2g}{}^1$ and intralayer $A_{1g}{}^1$ oscillations. Accompanied by changes in the hemisphere of the IR-reflection bands (297 and 357 cm^{-1}). The change (increase) of the half-width of the peaks and IR-reflection bands in the Raman spectrum is due to the change in the mechanism of interaction between the defects in the crystal and structural defects caused by γ-rays.

Surface reliefs of GaS and GaS:Yb layered monocrystals irradiated by gamma rays and thermal infus were studied by AFM-microscopy. Three-dimensional (3D) and two-dimensional (2D) images of surfaces were obtained. Based on the 2D descriptions, the distribution of nanoparticles in the horizontal and vertical directions was examined and it was determined that these distributions on the surface of GaS:Yb are homogeneous and periodic to the surface of the GaS monocrystal. Studies have also shown that γ-radiation disrupts periodicity and leads to heterogeneity, while thermal evaporation, in turn, restores homogeneity. It has been shown that the surfaces of GaS:Yb layered monocrystals are more sustainable to radiation in the considered dose range (D_γ = 30-200 krad) than the surface of GaS monocrystal, which is reflected in the horizontal distribution of nanoparticles.

Table. Dependence of GaS and GaS:Yb samples on the infusion temperature of the TO phonon hemisphere ($\nu_{1/2}$(TO) cm^{-1}).

№	Sample	$\nu_{1/2}$(TO) cm^{-1}
1	GaS	-
2	GaS T=100°C	52
3	GaS T=150C	50
4	GaS T=200°C	53,5
5	GaS T=250°C	50
6	GaS:Yb	64,5
7	GaS:Yb T=100°C	62
8	GaS:Yb T=150°C	53
9	GaS:Yb T=200°C	58
10	GaS:Yb T=250°C	56

The surface relief of gamma-irradiated GaS and GaS:Yb monocrystals were studied by Atomic Force Microscopy (AFM) and Fourier-IR spectroscopy and determine that different heights ~(30-40 nm) and periodicity ~16 nm heterogeneous distribution for GaS crystals is characteristic. When a crystal added by Yb atoms, the surface roughness, height ~25 nm and periodicity ~13 nm are reduced. Irradiation of GaS monocrystals with Yb atoms at a dose of D_γ<140 krad leads to a redistribution of defects, as a result, a decrease of the half-width in the free unit volume, and vice verse ,an increase above the dose of D_γ>140 krad observed.

Depending on the dose of γ-radiation in the Fourier-IR spectrum (D_γ=30-200 krad) changes in the reflection coefficients are observed on the surface of GaS and GaS:Yb monocrystals, on the basis of these changes has been determined that impuritied monocrystals are more sustainable to radiation. The average unit volume of the cone forming the relief was used as the surface characteristics of the layered crystals. The regression dependence of the average unit volume of the relief-forming cone, expressed in the exponential form $V=A^{*}e^{kx}$, on the effect of the degree of radiation is given.

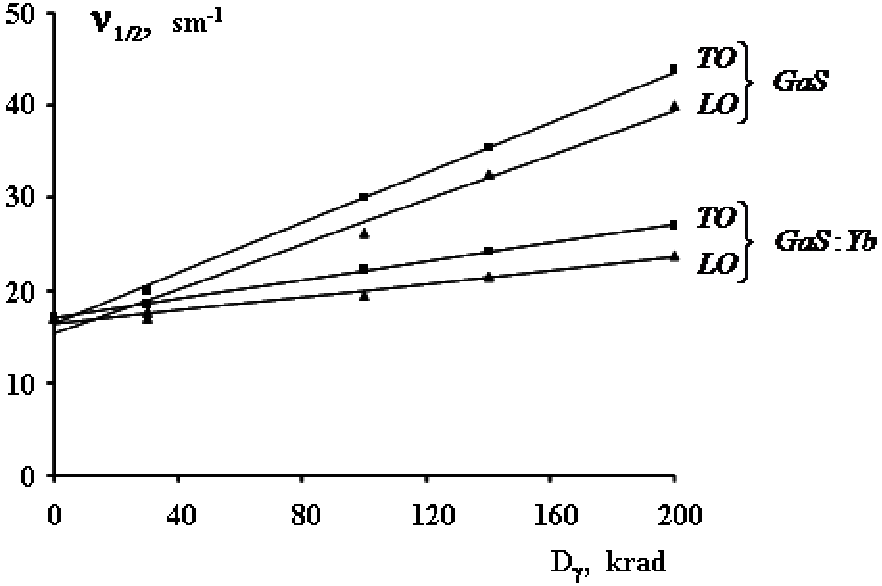

Figure 3. Dose dependences of the half-width ($\nu_{1/2}$) of the absorption bands of TO and LO optical phonons after γ-irradiation in GaS and GaS crystals.

A correlation between the free uniform volume distribution profile of inhomogeneity obtained by AFM and Fourier-IR spectroscopy methods and the radiation resistance of GaS:Yb layered monocrystals was determined.

MAIN RESULTS PRESENTED FOR DEFENCE

1. It was found that the photosensitivity of GaS and GaS:Yb layered monocrystals in the UV- region of the spectrum depends on the mobility of the photo charge carriers, which depends on the degree of flattening of the energy zone due to the non-uniform distribution of defects (V_{Ga}; V_S; Yb_{Ga}). According to the "field effect", if the value of the external electric field is U_n> 0, the photosensitivity increases due to the increase of mobility of the photo charge carriers, and decreases when U_n <0.

2. It was found that the degree of irregularity of surface defects in GaS layered monocrystals and its periodicity depends on the impurity degree. AFM study shows that in the surface area of a GaS monocrystals, the size of a conical defect set with a height of ~ (30-40) nm and periodicity of ~ 16 nm is partially regulated during implanted by Yb atoms (N_{Yb} = 0.1 at.%) And its height is ~ 25 nm. , the periodicity is ~ 12 nm.

3. It was determined that the degree of irregularity of surface defects in layered GaS and GaS:Yb monocrystals and its periodicity depend on the radiation dose of γ-rays. Thus, the regulation of defects in GaS - crystals are observed at doses of D_γ <50 krad, and in GaS: Yb crystals at D_γ <140 krad. At doses of γ-rays radiation D_γ > 50 krad and D_γ > 140 krad, respectively, the geometric dimensions of the conical defect accumulation increase, its periodicity is disturbed and the degree of regularity of the crystals decreases.

4. It has been shown that the increase in photosensitivity in the absorption band of the layered GaS monocrystal occurs due to the increased mobility of photo charge carriers as a result of partial compensation of structural defects at low doses of γ-quantum radiation and implantation of Yb atom.

5. It was found that in the region of the absorption dose range of gamma radiation Dγ = 30 ÷ 200 krad, with increasing the absorption dose the half-width of IR-absorption bands of Raman peaks and optical (transverse and longitudinal) phonons characterizing interlayer E_{2g}^1 and intralayer A_{1g}^1 oscillations in GaS

and GaS: Yb layered monocrystals increases ~2.5 times. The observed effect is associated with an increase in surface irregularities and changes in the mechanism of interaction between surface defects and radiation defects. It has been shown that thermal infusion (T = 100-250^{0}C) partially restores the regularity of surface conditions.

6. As a result of comparative studies of the surface of GaS and GaS: Yb layered single crystals by Fourier IR-reflection spectroscopic and surface relief by AFM-microscopic methods the dependence of the average unit volume of the relief-forming cone on the radiation dose was determined. It has been shown that the surfaces of GaS:Yb layered monocrystals are more sustainable to γ-rays in the region of absorption dose (D_γ = 30 ÷ 200 krad) than the surface of GaS monocrystal.

Published scientific works on the topic of the dissertation

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