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Photoluminescence of solid solutions $GaS_{1-x}Se_x$<Er> 0.1at% (X=0.20) irradiated with gamma-quanta

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PHOTOLUMINESCENCE OF SOLID SOLUTIONS $GaS_{1-x}Se_x$<Er> 0.1at% (X=0.20) IRRADIATED WITH GAMMA-QUANTA

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Abstract: It has been investigated the photoluminescent properties of undoped and rare-earth element erbium - doped solid solutions $GaS_{1-x}Se_x$<Er>0.1at% irradiated with gamma-quanta. Erbium doping reduces the photoluminescence intensity in solid solutions. After irradiation D_γ = 100 krad, the photoluminescence intensity increases. An increase in the photoluminescence intensity in irradiated solid solutions is explained by a decrease in the concentration of centers responsible for the fast recombination channel and associated with lattice defects.

Keywords: radiation, intensity, photoluminescence, doping, energy

1. Introduction

Recently, chalcogenide semiconductors activated by rare earth elements have been intensively studied. Doping of semiconductor materials with rare earth elements gives them photoconductive and luminescent properties [1-3]. The increased interest in these compounds is caused by the fact that, despite the strong defectiveness, they have high photosensitivity to visible, ultraviolet, X-ray, and gamma radiation [4, 5]. The nature of luminescence in the visible region of the spectrum and, in particular, green luminescence, despite a huge number of studies, is still a subject of discussion. Taking this circumstance into account, this work presents the obtained experimental data, which makes it possible to develop an approach to understanding the nature of luminescence in $GaS_{1-x}Se_x$<Er>0.1at%.

2. Methods of the experiment

The effect of γ-radiation with an energy of E=1.33 MeV and a dose of D_γ = 0, 30, 100 krad on the photoluminescence properties of solid solutions $GaS_{1-x}Se_x$<Er>0.1at% was investigated. The investigated solid solutions with a resistance of 10^9 ohm at room temperature were grown by the Bridgman method. Erbium doping was carried out during the growing process. The samples were irradiated using a Co^{60} installation at room temperature. The photoluminescence spectra of the studied samples were recorded on an SDL-1 spectrometer. The spectrometer consists of a double monochromatic with replaceable diffraction gratings, an illuminator with a DRSH-type lamp, a capacitor, energy receivers and an amplifier-recording device. A high-pressure mercury lamp DRSH-250-3 and DRSH-500m is used to excite luminescence. The sample is placed in a holder and illuminated by a powerful monochromatic flux, which is isolated using a light filter (337.1 nm) from the spectrum of a mercury lamp. The energy receiver in the spectrometer was an FEU-39A and FEU-62 photomultiplier tubes. The emission curves were recorded by a KSP-4 electronic self-searching potentiometer.

3. Results and Discussion

The photoluminescence spectra of solid solutions $GaS_{1-x}Se_x$ undoped and doped with the rare-earth element erbium at 77K in the wavelength range from 420nm to 620nm were studied (Fig. 1). At nitrogen temperature in solid solutions, the maximum of the intense band is 540nm. In addition to the main intense emission band, there is also a band with a maximum of about 495 nm. The maximum observed in the luminescence spectra of solid solutions is probably due to the transition of electrons from the conduction band to acceptor levels, which are 0.22 and 0.43 eV above the top of the valence band.

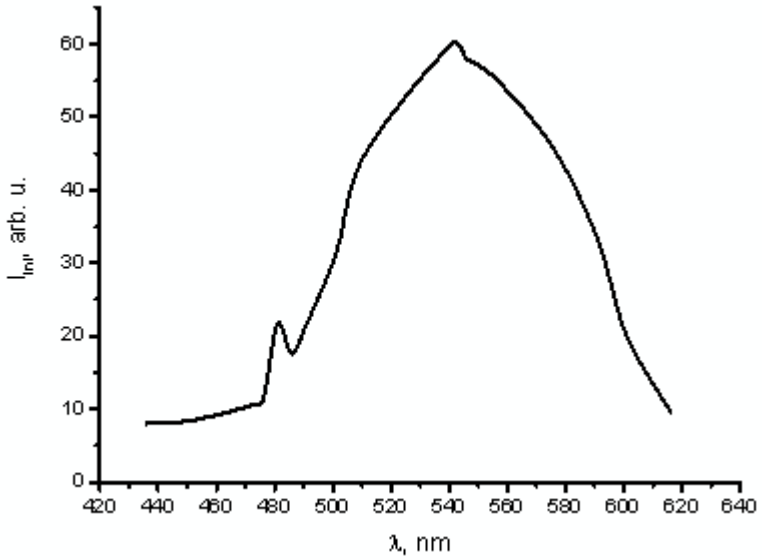

Fig. 1. Photoluminescence spectra of solid solutions $GaS_{1-x}Se_x$ 77K before irradiation.

In erbium-activated solid solutions $GaS_{1-x}Se_x$, the photoluminescence intensity decreases and narrower lines appear in the spectrum, which are related to intracenter transitions of introduced rare-earth impurities (Fig. 2.) After irradiation with γ-quanta with a dose of 30 krad (Fig. 3.), new high-intensity radiation peaks appear in the 550-560nm region in solid solutions $GaS_{1-x}Se_x$<Er>0.1at%.

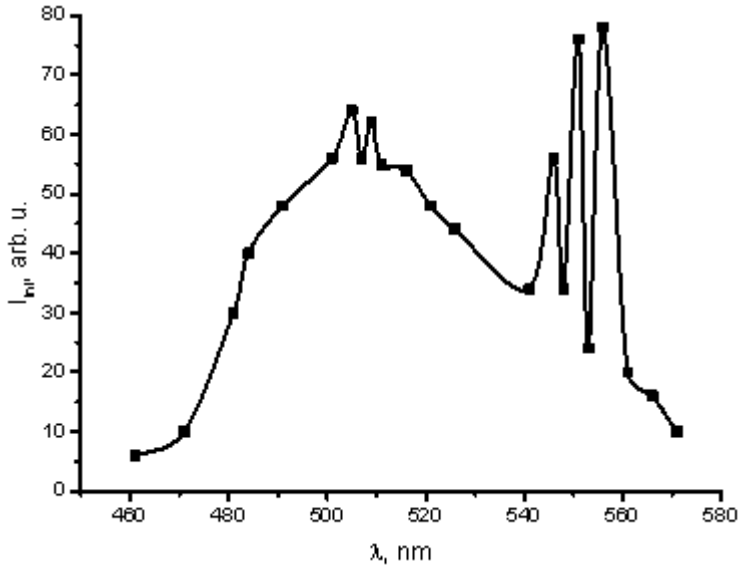

Fig. 2. Photoluminescence spectra of solid solutions $GaS_{1-x}Se_x$<Er>0.1am% at 77K before irradiation.

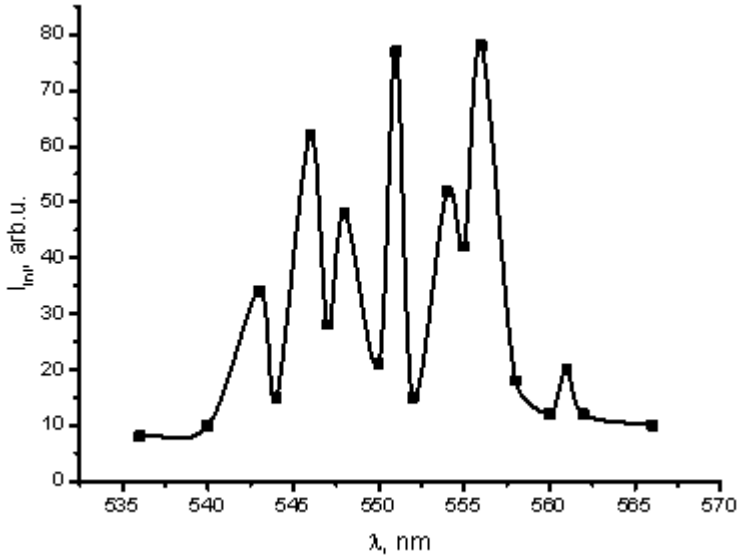

Fig. 3. Photoluminescence spectra of solid solutions $GaS_{1-x}Se_x$<Er>0.1am% at 77K after irradiation D_γ=30 krad.

Irradiation with a dose of D=100 krad (Fig. 4) leads to an increase in the line intensity in the range of 550-560 nm. The increase in the green luminescence intensity can be explained by the decay of bound Frenkel pairs in the sulfur sublattice, which, together with the separated pairs, are formed upon gamma irradiation of the samples. The appearance of new lines and a change in the relative line intensities known for the studied samples are interpreted as a consequence of the migration of defects arising from the displacement of sulfur atoms and their binding to rare-earth ions. At T=77K, free S_I and V_S arise in the sulfur sublattice due to the decay of bound Frenkel pairs. S_i defects are responsible for increasing the intensity of the green luminescence band.

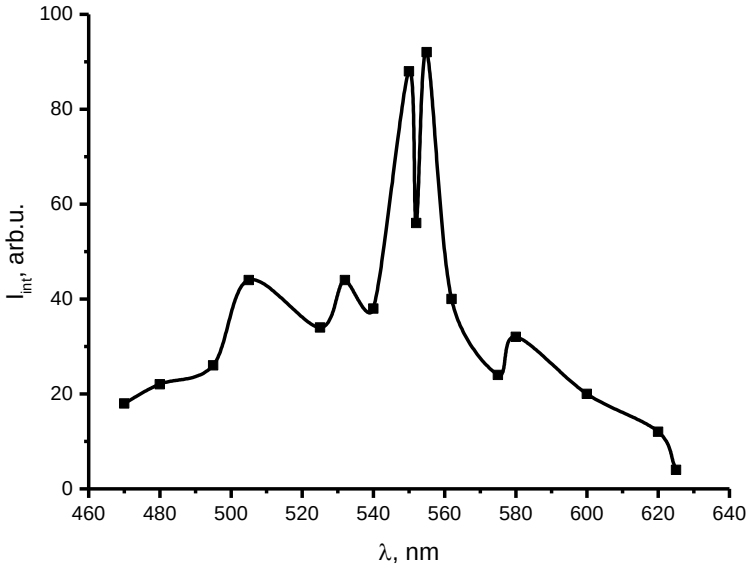

Fig. 4. Photoluminescence spectra of solid solutions $GaS_{1-x}Se_x$<Er>0.1am% at 77K after irradiation D_γ=100 krad.

The redistribution of the photoluminescence intensity in the range of 0.520 - 0.600 μm is due to the transfer of energy to the rare-earth centers in the activated crystals. The observed number of bands in the spectrum and their narrowness give reason to believe that Er^{+3} ions occupy mainly one position in the studied samples, forming the main erbium center. Along with the main Er^{+3} - center, complexes consisting of Er^{+3} ions, intrinsic crystal defects, or uncontrolled impurities can form in the studied samples. This is evidenced by the results of a study of photoluminescence, which allowed several erbium centers. The existence of several types of erbium centers in these crystals is associated with the substitution of impurity ions for various regular positions in the crystal lattice and various mechanisms for compensating the excess charge.

4. Conclusion

The performed investigations allow us to conclude that doping with erbium leads to the appearance of a series of emission lines in the visible region of the spectrum. The detected luminescence bands of solid solutions $GaS_{1-x}Se_x$<Er>0.1at% are the result of intracenter transitions in the Er^{+3} ion.

After irradiation with γ-quanta, free S_i and V_s appear in the sulfur sublattice due to the decay of bound Frenkel pairs. S_i defects are responsible for an increase in the intensity of the green luminescence band.

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ФОТОЛЮМИНЕСЦЕНЦИЯ ТВЕРДЫХ РАСТВОРОВ $GaS_{1-x}Se_x$<Er> 0,1ат% (X=0.20) ОБЛУЧЕННЫХ ГАММА- КВАНТАМИ

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Резюме: Исследованы фотолюминесцентных свойств нелегированных и легированных редкоземельным элементом эрбием твердых растворов $GaS_{1-x}Se_x$<Er> 0,1ат% облученных гамма-квантами. Легирование эрбием уменьшает интенсивность фотолюминесценции в твердых растворов. После облучения D_y=100крад интенсивность фотолюминесценции увеличивается. Увеличение интенсивности фотолюминесценции в облученных твердых растворах объясняется

уменьшением концентрации центров, ответственных за канал быстрой рекомбинации, связанных, с дефектами решетки.

Ключевые слова: излучения, интенсивность, фотолюминесценция, легирования, энергия.

QAMMA KVANTLARI İLƏ ŞÜALANDIRILMIŞ $GaS_{1-x}Se_x$<Er>0,1at%(x=0,20) BƏRK MƏHLULUNUN FOTOLÜMİNESSENSİYASI.

R.S. Mədətov, T.B. Tagiyev, A.Z. Abasova

Xülasə: Qamma kvantları ilə şüalandırılmış təmiz və nadir torpaq elementi erbi ilə aşqarlanmış $GaS_{1-x}Se_x$ bərk məhlulunun fotolüminessensiya xasssələri tədqiq edilmişdir. Bərk məhlulu Er ilə aşqarladıqda fotlüminessensiyanın intensivliyi azalır. D_y=100krad doza ilə şüalandırdıqda fotolüminessensiyanın intensivliyi artır. Şüalandırılmış $Ga_{1-x}Se_x$<Er> bərk məhlulunda fotolüminessensiyanın intensivliyinin artması qəfəs defektləri ilə əlaqəli olan sürətli rekombinasiya mərkəzlərinin konsentrasiyasının artması ilə izah olunur.

Açar sözlər: Şüalanma, intensivlik, fotolüminessensiya, aşqar, enerji.