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PHOTOLUMINESCENCE OF UNDOPED AND Yb-DOPED GaS SINGLE CRYSTALS IRRADIATED WITH γ-QUANTA

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The infuence of γ-radiation with a dose Dγ = 140 krad on the photoluminescence of Yb-doped GaS single crystals was investigated. Based on the analysis of the experimental results, it is concluded that the doping of the rare-earth element Yb and γ-radiation leads to an increase in the intensity of photoluminescence radiation in GaS.

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INTRODUCTION

In recent years, studies of the luminescence of ions of rare-earth metals in single crystals of semiconductors of A^3B^6 compound are of increasing interest [1–3].This is due to the fact that in semiconductors effective energy transfer to rare-earth ions is possible with optical zone-band excitation and impact excitation of impurity centers by current carriers in an electric field [4]. Gallium sulfide with a energy gap width (Eg = 2.53 eV) has excellent optical and luminescent properties. It is applied as phosphors, transparent contacts, varistors. There are a number of reviews describing the structural, optical, and luminescent characteristics of GaS [5, 6].

TECHNIQUE OF EXPERIMENTS

The investigated single crystals of GaS, GaS<Yb>0.1 at% were grown by the Bridgman methods and had p-type conductivity. Ytterbium doping was carried out during the growth process. Irradiation of the samples with γ-quanta with energy Eγ = 1.33 MeV was carried out on an installation assembled on the basis of Co^{60} at room temperature. The photoluminescence spectra of the studied samples were recorded on a Perkin Elmer LS-55 luminescence spectrometer. For exciting samples, it has been used a xenon lamp with a power of 150 W, operating in a pulsed mode with a frequency of 50 Hz. The sample is placed in a holder and illuminated with a powerful monochromatic flux, selected using a light filter (λ = 337 nm) from the spectrum of a xenon lamp. The control is carried out from a personal computer using the FL WinLab program.

RESULTS AND ITS DISCUSSION

It has been shown the photoluminescence spectra of undoped (Fig. 1) and ytterbium-doped (Fig. 2) single crystals of GaS at T = 300 K in the wavelength range from λ = 450 nm to λ = 650 nm. At room temperature, the dominant emission band in both undoped and doped single crystals was structureless green luminescence. The maximum of the band of undoped samples corresponded to the wavelengths 512.5, 522.5, 527.5, 530, 547.5 nm. The introduction of the Yb impurity causes an increase in its intensity. At a temperature of T = 300 K, the positions of the band maxima of undoped and doped crystals practically coincide.

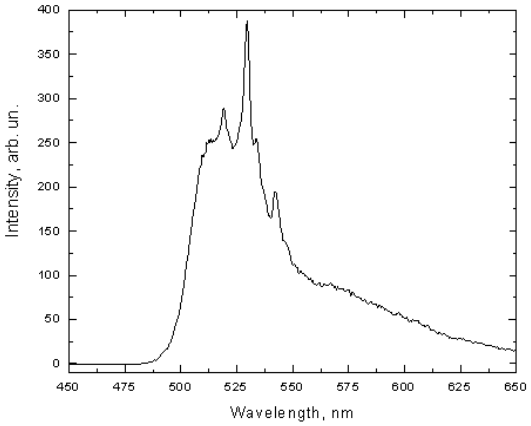

Fig. 1. Photoluminescence spectrum of undoped GaS single crystals at T = 300 K

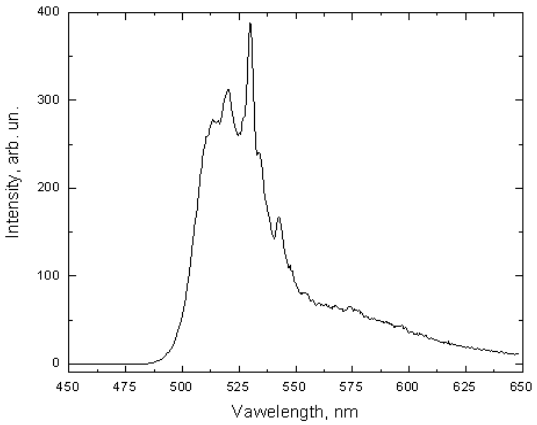

Fig. 2. Photoluminescence spectrum of Yb-doped Gas

It is known that spectra, in which interstitial sulfur atoms have an important role, are responsible for the green luminescence band at T = 300 K. In this case, radiation occurs during the recombination of free electrons with holes captured by Si acceptors by YbGa donor centers, which are filled with electrons at T = 300 K temperature, leading to a practical coincidence of the maxima of green luminescence of doped and undoped crystals at T = 300 K. After irradiation of doped GaS samples with γ-quanta with a dose of Dγ = 140 krad led to an increase in the luminescence intensity, but their PL spectra acquire features characteristic of the spectra of undoped crystals (Fig. 3).

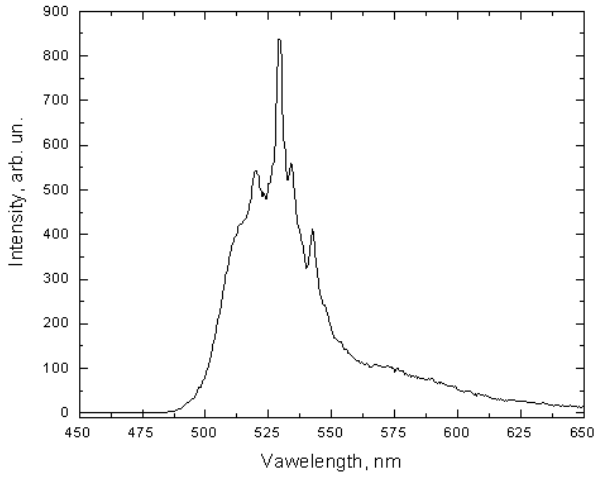

Fig. 3. Photoluminescence spectrum of Yb-doped GaS single crystals after irradiation with gamma quanta with a dose of Dγ = 140 krad

An increase in the PL intensity in irradiated single crystals is explained, on the one hand, by an increase in the concentration of slow recombination centers, which include V_{Ga}, and, on the other hand, by a decrease in the concentration of centers responsible for the nonradiative recombination channel associated with lattice defects.This change is mainly due to the appearance of a large number of radiation structural defects, which are centers of radiative recombination. It is possible that irradiation introduces defects that form complexes with existing recombination centers, reducing their role in the process of recombination of carriers specified by light. The detected luminescence bands of GaS (Yb) crystals are the result of intracenter transitions in the Yb^{+3} ions. The addition of Yb to GaS single crystals is likely to lead to the substitution of Ga atoms, and that the intracenter luminescence is due to the transitions of Yb^{+3} ions between the $^2F_{5/2} - {}^2F_{7/2}$ states.

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ФОТОЛЮМИНЕСЦЕНЦИЯ НЕЛЕГИРОВАННЫХ И Yb-ЛЕГИРОВАННЫХ МОНОКРИСТАЛЛОВ GaS, ОБЛУЧЕННЫХ γ-КВАНТАМИ

Р.С. Мадатов, Т.Б. Тагиев, А.Ш. Халыгзаде

Исследовалось влияние γ-излучения с дозой Dγ=140 крад на фотолюминесценцию монокристаллов GaS, легированных Yb. На основе анализа экспериментальных результатов делаются выводы, что при легировании примесями редкоземельного элемента Yb и γ-излучений интенсивность фотолюминесцентного излучения в GaS увеличивается.

ФОТОЛЮМІНІСЦЕНЦІЯ НЕЛЕГОВАНИХ І Yb-ЛЕГОВАНИХ МОНОКРИСТАЛІВ GaS, ОПРОМІНЕНИХ γ-КВАНТАМИ

Р.С. Мадатов, Т.Б. Тагієв, А.Ш. Халигзаде

Досліджувався вплив γ-випромінювання з дозою Dγ = 140 крад на фотолюмінесценцію монокристалів GaS, легованих Yb. На основі аналізу експериментальних результатів робляться висновки, що при легуванні домішками редкоземельного елемента Yb і γ-випромінювань інтенсивність фотолюмінесцентного випромінювання в GaS збільшується.