PHOTOCONDUCTIVITY OF $(GaSe)_{0.8}(InSe)_{0.2}$ MONOCRYSTAL AND INFLUENCE ON IT OF IRRADIATION WITH γ-QUANTUMS

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The spectral characteristics of photoconductivity with ordinary and polarized light at different temperatures in $(GaSe)_{0.8}(InSe)_{0.2}$ crystals were analyzed, and it was shown that their nature corresponds to that of GaSe. The effect of γ-ray irradiation was not observed.

Keywords. Solid solution, laser, exciton annihilation, carrier recombination, spectral characteristics.
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For a long time, the production of semiconductor compounds belonging to the $A^{III}B^{V}$ group and their solid solutions has been a focus of research. The chemical nature and structural characteristics of $A^{III}B^{V}$ type compounds are of particular interest when studying their photoelectric properties. Their layered monocrystals resemble $A^{II}B^{VI}$ compounds (such as CdS and CdSe) in terms of atomic coordination and the nature of the bonding, which gives them very high photoconductivity [1].

Like other layered crystals from the $A^{III}B^{V}$ group, GaSe and InSe monocrystals also have a defective structure, and the role of defects with a high concentration is significant in the formation of photoconductivity. The defects can be controlled by introducing various amounts of different dopants into the crystals and irradiating them.

Due to their favorable parameters for applications in optoelectronics, microelectronics, and solar energy utilization, GaSe and InSe compounds are more widely studied.

In the present study, some photoelectric properties of $(GaSe)_{0.8}(InSe)_{0.2}$ solid solution monocrystals, which exhibit high photosensitivity over a wide optical range, were investigated, along with the effect of γ-ray irradiation on them.

The Ga-In-Se ternary system is characterized by limited crystal formation up to 10 mol % GaSe or 20 % InSe, or the formation of the unstable ternary compound Ga_2InSe_3. Crystals with the composition $(GaSe)_{0.8}(InSe)_{0.2}$ differ significantly from the initial components, which is why this specific composition was studied. The samples under investigation were synthesized by taking stoichiometric amounts of the GaSe and InSe compound ligatures, and their monocrystals were grown using the Bridgman and Czochralski methods.

Based on their physical properties, the obtained pure crystals can be divided into two groups (Group I and Group II). The specific resistance of Group I crystals was $\rho = 10^2 - 10^4\ \Omega\cdot$cm, while the high-resistance Group II crystals had a resistance of $\rho = 10^8 - 10^9\ \Omega\cdot$cm. Silver paste was applied to the $5\times3\times0.8$ mm³ samples to form ohmic contacts. The investigation of the voltage-current characteristic revealed that, at applied voltages up to 100 V, the voltage-current characteristic was linear for Group I crystals, while for Group II crystals, it was exponential. This dependence can be explained by the volumetric inhomogeneity present in the studied crystals.

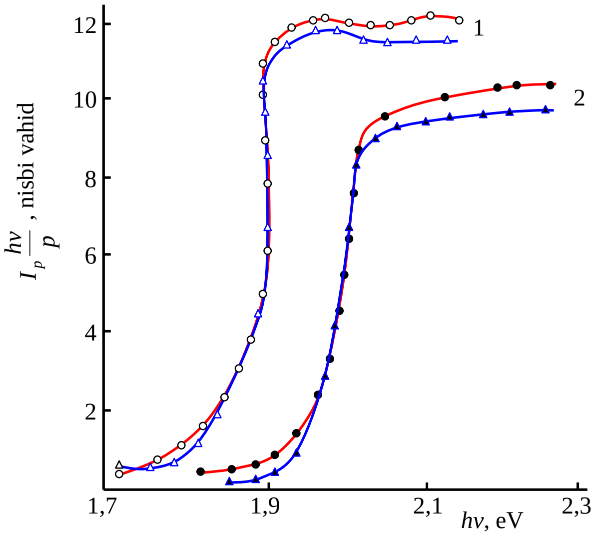

Fig. 1. Photoconductivity curves of Group I $(GaSe)_{0.8}(InSe)_{0.2}$ crystals at 300 K (1) and 77 K (2) temperatures, measured with polarized light (in blue) and ordinary light (in red).

The photoconductivity of $(GaSe)_{0.8}(InSe)_{0.2}$ crystals was measured at 77 K and 300 K using both ordinary and polarized light. The light was applied perpendicular to the layers, while the electric field was applied parallel to the layers. The light was modulated at a frequency of 30 Hz. The spectral dependence of the photoconductivity for Group I crystals is shown in Figure 1. In all the samples tested, a maximum was observed at an energy of 1.9 eV at room temperature and 2.0 eV at 77 K. These maxima can be explained by the annihilation of excitons. For Group I samples, the decrease in photoconductivity was found to be consistent with the calculated value for the width of the forbidden zone, which corresponds to the forbidden zone width of GaSe crystals [2, 3, 4].

Therefore, the similarity of the properties of GaSe was observed in $(GaSe)_{0.8}(InSe)_{0.2}$ crystals. However, unlike in [1], no effect of light polarization on photoconductivity was observed.

In Group II crystals, no maximum was observed at room temperature, which could be explained by exciton annihilation (Figure 2).

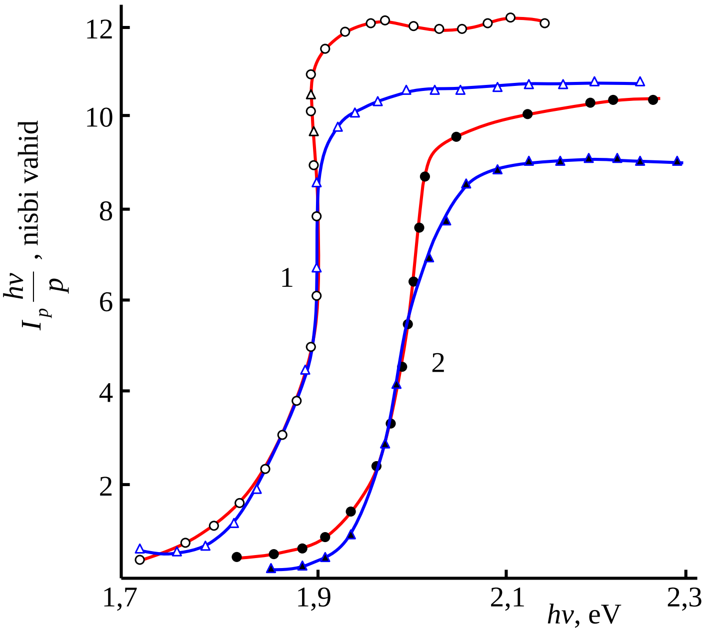

Fig. 2. Photoconductivity curves of Group II $(GaSe)_{0.8}(InSe)_{0.2}$ crystals at 300 K (1) and 77 K (2) temperatures, measured with polarized light (in blue) and ordinary light (in red).

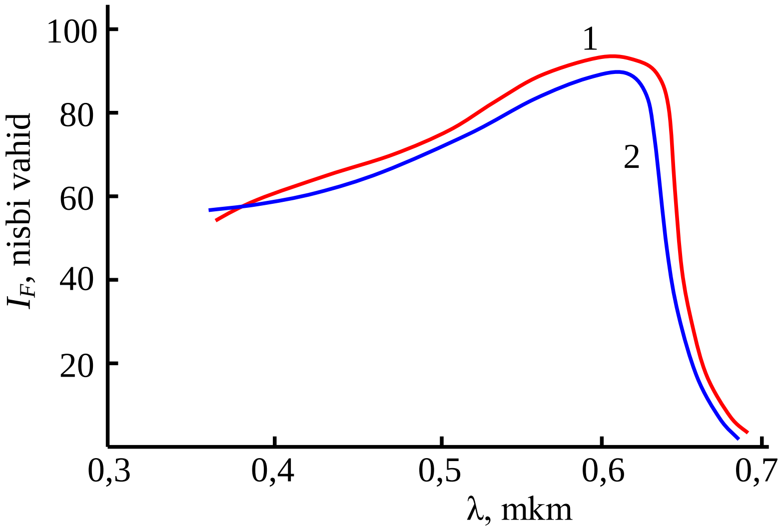

Fig. 3. Spectral dependence of photoconductivity for Group I $(GaSe)_{0.8}(InSe)_{0.2}$ crystals at 300 K, measured with ordinary light: 1 – before irradiation; 2 – after γ-ray irradiation.

However, when the temperature was reduced to 77 K, a negative photoconductivity region appeared in the spectral dependence of the photoconductivity. Such a characteristic is also observed in many photosensitive materials [2–4]. Since the studied compound is GaSe-type and GaSe exhibits p-type conductivity, the negative photoconductivity can be explained by the role of levels with small capture cross-sections near the top of the valence band, which are involved in conductivity. When the crystal is illuminated with low-energy photons from the forbidden zone, electrons in these levels are excited into the conduction band. However, they are quickly captured by recombination centers and subsequently recombine with free holes, resulting in a decrease in the concentration of free charge carriers and the observation of negative photoconductivity. From the spectral dependence of photoconductivity, the width of the forbidden zone for these types of samples was calculated to be 1.85 eV.

As seen in the figure, as the temperature decreases, the long-wavelength edge of the photoconductivity shifts toward shorter wavelengths. Based on this shift, the temperature coefficient of the forbidden zone width was calculated to be 6×10^{-4} eV/K for Group I crystals and 4×10^{-4} eV/K for Group II crystals.

The difference observed in the physical properties of various samples of the $(GaSe)_{0.8}(InSe)_{0.2}$ crystal is explained by the presence of inhomogeneity. As a result, peaks in the spectrum, which would normally be attributed to exciton annihilation, are not observed.

The study also investigated the effect of γ-ray irradiation with a dose of 2.58×10^2 Kr/kq on the photoconductivity of Group I $(GaSe)_{0.8}(InSe)_{0.2}$ crystals. It was determined that the crystals are resistant to this level of irradiation (Figure 3).

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