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ELECTRICAL CONDUCTIVITY OF STRONGLY COMPENSATED $In_{0.93}Sm_{0.07}Se$ CRYSTALS

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The electrical properties of $In_{0.93}Sm_{0.07}Se$ monocrystalline irradiated in the temperature interval 142-294K with $D\gamma$=(50,70,80,90 and 100)krad were studied. When irradiated with γ-quanta with a dose 50 krad $In_{0.93}Sm_{0.07}Se$ crystals. Electrical conductivity decreases due to compensation of uncontrolled defect centers. At subsequent high doses of radiation, no additional defect centers are formed, but the concentration of the previous centers increases, which leads to an increase in electrical conductivity. The activation energy of charge carriers decreases with increasing dose of γ-irradiation. $In_{0.93}Sm_{0.07}Se$ monocrystalline semiconductors are used for diapazonation.

Keywords: ideal crystal, rare earth elements, compensation, electrical conductivity.
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1. INTRODUCTION

Indium selenide (InSe) is a semiconductor with unique electrical properties, which is constantly in the focus of researchers. One of the main features of the InSe crystal is its strong anisotropy of electrical conductivity, which is equal to 10^4 at T<100K [1]. Various methods are used to expand the operating range of devices based on InSe single crystals and to control them. One of these methods is to partially replace In atoms with Sm atoms in InSe single crystals. Rare earth elements are dissolved in small quantities in the substance, they purify semiconductors, thereby reducing the concentration of defects and, as a result, increasing the mobility of charge carriers. Earlier in [2] we have conducted investigations on studying the electrical properties of unirradiated $In_{0.9993}Er_{0.0007}Se$ crystals irradiated with γ-quanta with a dose of50 and 100 krad.

At a temperature of 300K, the equilibrium concentration of charge carriers for a p-InSe single crystal was $p_0=1.84\cdot10^{13}$cм$^{-3}$, and the mobility μ_o=85sм^2/V·s. [3].

The equilibrium carrier concentration for $In_{0.93}Sm_{0.07}Se$ single crystals at a temperature of 294K was $n_0=8.0\cdot10^{16}$cм$^{-3}$, σ=0.03342om^{-1}·cm^{-1}, R_x=60.25sm^3/Kl, and mobility μ_o=2.01sм^2/V·s. [4].

The main goal of studying the electrophysical properties of $In_{0.93}Sm_{0.07}Se$is to expand the operating range of devices based on these single crystals and to control their performance.

2. EXPERIMENTAL RESULTS AND DISCUSSION

The coordination number of the metal atoms in InSe is 4, while the coordination number of the Se atoms is 3. Accordingly, the 4-coordinated In atom forms a tetrahedral bond with the 3-coordinated Se atom, and one In atom undergoes sp3 hybridization due to the s2p electron. This allows us to conclude that the nature of the chemical bond between indium and samarium monoselenides is similar. This facilitates the formation of solid solutions between InSe and SmSe [5].

To study the electrical properties, homogeneous $In_{0.93}Sm_{0.07}Se$ single crystals were obtained. The following chemical elements were used: In - In 000, Se - B-3, and Sm - Cm-1. The chemical elements In, Sm, and Se, weighed according to stoichiometry, were loaded into a quartz ampoule, which was then evacuated to a residual pressure of 10^{-4} Pa. $In_{0.93}Sm_{0.07}Se$ single crystals were grown using the Bridgman method in a vertical furnace. The ampoule movement rate in the furnace was 3 mm/hour. All alloys obtained in this manner were analyzed using differential thermal analysis and X-ray diffraction. Their densities, microhardness, and electrical properties were measured. Using the obtained results, a phase diagram of the InSe–SmSe system was constructed. Based on this phase diagram, the solubility of SmSe in InSe was determined: 7.1 mol% at room temperature and 7.8 mol% at 520°C.Modern and precise measuring instruments (DSC-910, ADVNCE-8D, SINTECP-21, DRON-4-07 using CuKα radiation with a step of 0.05 in the angular range of 8-135°, SEM from Zeiss with an energy-dispersive analyzer) were used to conduct the experiments. It was found that the $In_{0.93}Sm_{0.07}Se$ single crystal has the following crystal lattice parameters: a = 4.16 Å, c = 17.02 Å, c / a = 4.09, space group P6322 and hexagonal modification. The width of the crystalline sample is 300 µm, and the contact area is $2\cdot10^{-2}$ cm². Silver paste was used as a contact material. The effect of γ-irradiation in the temperature range of 142–294 K on the electrical conductivity of $In_{0.93}Sm_{0.07}Se$ crystals was studied for the first time using the compensation method in a constant electric field according to the technique. Silver paste was used as the contact material. The contacts were placed on opposite faces of the samples, which had the shape of a parallelepiped with dimensions of 10×4×2 mm^3.

The samples were irradiated using an RKHUND-20000 setup (a continuous-action radiation chemical setup) with a quantum energy of 1.25 MeV and irradiation doses Dγ = 0; 10; 30; 50; 70; 80; 90 and 100 krad. The radiation flux density was $1.4 \cdot 10^{11}$ quantum/s·cm^2. In all measurements, the current flowed through the sample, and the magnetic field wasOriented perpendicular to the crystal surface. Based on the sign of the thermoelectric power, it was determined that $In_{0.93}Sm_{0.07}Se$ solid solutions exhibit n-type conductivity.

When $In_{0.93}Sm_{0.07}Se$ crystals are irradiated with γ-rays at a dose of 50 krad, the electrical conductivity decreases due to compensation of uncontrolled defect centers.

Figure 1 shows the temperature dependence of the electrical conductivity of $In_{0.93}Sm_{0.07}Se$ crystals.

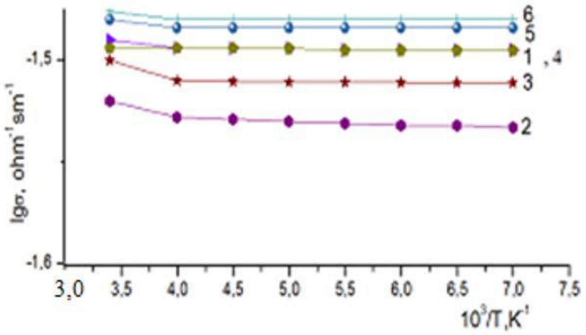

Fig. 1. Temperature dependence of electrical conductivity of $In_{0.93}Sm_{0.07}Se$ crystals; numbers 1, 2, 3, 4, 5, 6 indicate, respectively, the curves for unirradiated crystals and those irradiated with a dose of Dγ = 50 krad, 70 krad, 80 krad, 90 krad and 100 krad.

At subsequent high doses of irradiation, no additional defect centers are formed, the concentration of the previous centers increases, which leads to an increase in electrical conductivity.

3. CONCLUSION

Thus, upon irradiation of $In_{0.93}Sm_{0.07}Se$ crystals with γ-rays with a dose of 50 krad. Electrical conductivity decreases due to compensation of uncontrolled defect centers. At subsequent high doses of irradiation, no additional defect centers are formed, the concentration of the previous centers increases, which leads to an increase in electrical conductivity.The activation energy of charge carriers decreases with increasing dose of γ-irradiationIt is possible to expand the operating range of devices based on $In_{0.93}Sm_{0.07}Se$ single crystals and control their performance.

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