Baku State University: Journal of Physics & Space Sciences, **2025**, v 2 (1), p. 55-57

journal homepage: http://bsuj.bsu.edu.az/en

Effect of gamma quanta on photoelectric properties of $TlGaSe_2$ single crystals

Adela Z. Abasova, Lyudmila H. Hasanova*,
Alinaqi Z. Mahammadov, Sona A. Jahangirova

Department of Semiconductor Physics, Faculty of Physics, Baku State University, Baku, Azerbaijan
Received 25-Jan-2025; Accepted 12-Mar-2025
DOI: https://doi.org/10.30546/209501.101.2025.2.300.014

Abstract

This article discusses the radiation resistance of a $TlGaSe_2$ single crystal. For this purpose, the influence of gamma quanta of different doses on the spectral dependences of single crystals at different temperatures was studied.

Keywords: photosensitivity, irradiation, bandgap.
PACS: 61.46.Df, 78.67.Bt, 79.60.Jv

1. İntroduction

In recent years, interest in compounds obtained on the basis of elements of the third and sixth groups of the periodic table has increased significantly. In particular, much attention is paid to relatively new classes of semiconductors: $A^{III}X^{VI}$ and $A^{III}B^{III}X_2^{VI}$, where B – Ga, In, and X – S, Se. This paper considers the photoconductivity of $TlGaSe_2$ single crystals and the effect of γ-quanta on these properties. $TlGaSe_2$ single crystals crystallize in a monoclinic lattice in the space group P2/m. The lattice parameters have the following features: a=b<c, $90^0<\beta<100^0$, z=16, the space group Cc has no center of symmetry [1]. The crystals are easily split in the (001) plane. The compounds form a layered crystal lattice with two anionic layers $[GaSe_2]^{1-}$. Adjacent layers are located to each other at an angle of 90^0. They are held

**Corresponding author*. Tel.: (+994) 50 337 40 76.
e-mail: ludmilahasanova@mail.ru; ORCID ID: 0009-0009-9974-0618.

by Tl^{1+} ions. Different possible arrangements of layers lead to one-dimensional disorder in the direction perpendicular to the cleavage plane.

Samples for photoconductivity studies were prepared by cleaving $TlGaSe_2$ single crystals onto plane-parallel plates. The illuminated plane of the sample was about 5×2 mm^2 in size, and the sample thickness varied within 0.05–0.5 mm depending on the study area. Silver paste was used as the material for ohmic contacts. The direction of light propagation was perpendicular or parallel to the cleavage plane, and the external electric field was applied along the cleavage plane. $TlGaSe_2$ has a fairly high photosensitivity at room temperature, and with decreasing temperature, it increases by two orders of magnitude, i.e., the ratio of dark resistance to resistance in the light, at 77 K is $\sim 10^3$.

In the photoconductivity spectrum taken at room temperature, there are steps and a maximum at the energy of 2.15 and 2.28 eV. A sharp drop in the photocurrent when the crystal is illuminated with light with an energy of < 2.3 eV indicates that the maximum observed at 2.3 eV corresponds to the maximum of the photocurrent. At a temperature of 77 K (Fig. 1), three clearly defined photocurrent maxima are observed at the energy of 2.15; 2.38 and 2.52 eV. The band gap width calculated from the long-wave boundary at 77 K and 293 K is 2.22 and 2.17 eV, respectively, and the average temperature coefficient is 2.3 eV/deg. The temperature coefficient and band gap width calculated from the spectral characteristics of the photoconductivity are in good agreement with the observed direct transitions in $TlGaSe_2$ crystals [2]. As the temperature increases, some structures on the photoconductivity spectral curve disappear, the maximum shifts toward lower energies and broadens. These effects are due to exciton-phonon interaction at high temperatures.

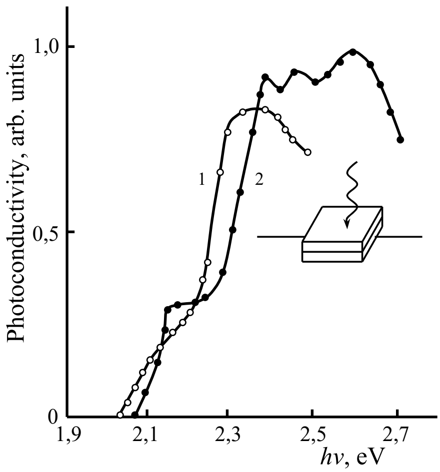

Fig. 1. Curves of spectral distribution of photosensitivity of $TlGaSe_2$ single crystal at different temperatures: 1 – 300 K; 2 – 80 K.

When studying crystals with a thickness of ≥ 0.3 mm, the decline in the photoconductivity spectra of $TlGaSe_2$ in the long-wave region becomes gentle as the wavelength increases, and the samples are sensitive in a longer-wave region. According to the Moss criterion, the band gap energy in this case is 2.13 eV and agrees well with the data of [3]. This value of the band gap is associated with impurity photoconductivity. Irradiation with gamma quanta up to a dose of 200 krad led to an increase in sensitivity in the entire spectral range (Fig. 2). The position of the maximum during irradiation with gamma quanta at a dose of 200 krad remained virtually unchanged; at a gamma quanta dose of up to 500 krad, an increase in photosensitivity in the region of intrinsic absorption was also observed, the photosensitivity increased by 4–5 times. Consequently, $TlGaSe_2$ single crystals, in the specified spectral range covering the region of maximum photosensitivity, can be classified as radiation-resistant photodetectors.

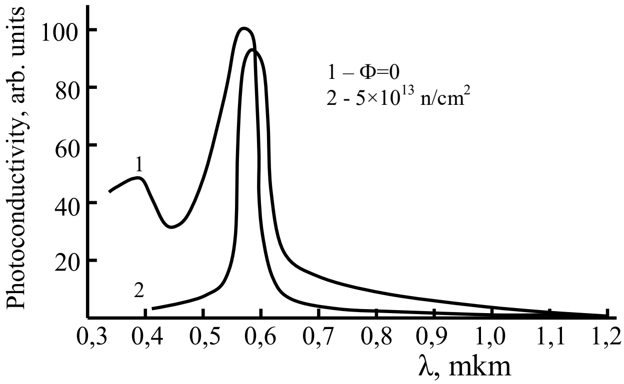

Fig. 2. Curves of spectral distribution of photosensitivity of $TlGaSe_2$ single crystal after irradiation with gamma quanta.

References

[1] Muller D.V., Hahn H. Lur struktur des $TlGaSe_2$. J. anorg. allg. chem., 1978, v. 438, № 3, p. 258-272.

[2] Baxishov A.E., Musayeva L.H., Lebedeva A.A., Yakobson M.A. Study of optical and photoelectric properties of $TlGaSe_2$ crystals. Semiconductors, 1975, v. 32, № 8, p. 1548-1551.

[3] Karpovich I.A, Chervova A.A., Demidova L.I., Leonov E.I, Orlov V.M. Optical and photoelectric properties of $TlGaS_2$, $TlGaSe_2$ and $TlInSe_2$ single crystals. Inorganic materials, 1972, v. 8, p. 70-72.