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Factors Affecting the Transparency of GaP Mono Crystals to Optical Radiation

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ABSTRACT: Process effect of the face of undopedGaP mono crystals on their optical clarity is analyzed. While lighting of polar border surface the light transmission anisotropy is revealed, in this case other conditions being equal lighting through border A(111) gives light-transmission factor to 10 % higher than in case of border B(111).

KEYWORDS: Single crystals, semiconductor, transmittance, grinding, polishing, chemical etching, anisotropy.

I.INTRODUCTION

Mono crystals of some wide-gap semiconductors are simultaneously used as a carrier of crystal and optical window in the development of optoelectronic structures [1,2]. Therefore, the study of factors affecting their optical transparency is of scientific and practical interest.

The influence of the method of processing the surface of GaP crystals on their transmittance of optical radiation is studied in this paper. To eliminate the effect of absorption on free charge carriers, undoped crystals with a thickness of d≈200 microns were used.

II. METHODS AND EXPERIMENT

The research methodology lies on the fact that with optical excitation of a crystal, a part of photons with energy hν is smaller than forbidden band of a semiconductor, penetrates to a recording narrow-band photo detector (PhDt) on the basis of Si, located under a wide-gap crystal. The magnitude of the photocurrent PhDt of the phase transition in such an optically coupled system depends on the transmittance T (λ) of the GaP radiation beyond the long-wave edge of the main absorption band of the wide-gap window [3]

$$T(\lambda) = (1-R_1)(1-R_2)\, e^{-\alpha d} \qquad (1)$$

where d- is the crystal thickness, R_1, R_2 -are the indexes of the reflection from the front and back surfaces, α is the absorption index of optical radiation, which is determined from the relation

$$\alpha = \frac{1}{d} ln \frac{(1-R_1)(1-R_2)}{T(\lambda)} \qquad (2)$$

The transmittance of a wide-gap crystal is studied from the ratio of photocurrent phase transitions for GaP with different initial parameters. Since, in the process of creating instrument structures, in particular epitaxial technology, the surface of carrying crystals undergoes such types of processing as polishing, chemical etching. Therefore we studied crystals of similar types.

As the research results show (Fig. 1), the magnitude of the photocurrent PhDt, respectively and T (λ), noticeably changes depending on the state of the GaP surface. When the surface of a crystal ground with M5 and M14 abrasive powder is illuminated, the value of PhDt decreases to 35 and 50%, (curves 2 and 3) compared to the photocurrent obtained by illuminating GaP plates smoothly polished with diamond paste (curve 1). In the case of using grinded surfaces, the semiconductor is known to have the lowest direct reflection coefficient. The decline of the photocurrent, despite the existence of this factor, can be explained by the dispersion of light scattered by a crystal [4].

To determine the effect of the thickness of the damaged layer on the value of T (λ) chemical etching of the GaP surface in a polishing etchant consisting of 1HNO3: 3HCl was carried out. From Fig. 1, it follows that as the surface of the machined crystal is etched, i.e. as the broken layer is removed, at first the photocurrent PhDt grows abruptly , and then slows down, tending to saturation.

In this case, as the surface of mechanically ground GaP is etched, the magnitude of the PhDt current is almost aligned with the PhDt current obtained using a smooth-polished optical window.

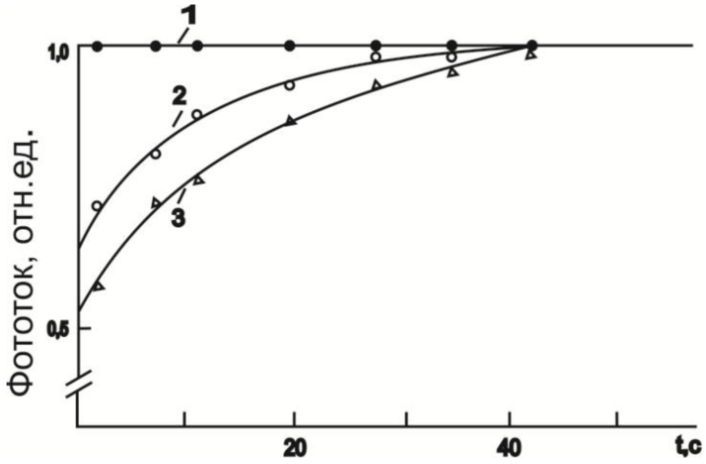

Fig.1. Dependence of the photocurrent on the time of chemical etching of the illuminated GaP surface with a different method of its processing: 1- diamond polishing, 2,3-grinding in the abrasive powder M5 and M14, respectively

Further etching (more than 50 s) of the crystal practically does not lead to an increase of the PhDt current. Therefore, the point of achievement of the maximum value of the PhDt current can be considered as a criterion for the absence of a broken layer and a sufficient quality of GaP surface treatment.

The observed different times of etching to achieve a fixed value of the photocurrent indicate different thicknesses of the broken layer. An increase of the PhDt current when the oxide film is applied to the etched surface indicates an increase in the value of T (λ) due to a decrease in the reflection coefficient in the spectral band under study.

It was experimentally observed an increase in the anisotropy of T (λ) during the mechanical processing of the GaP polar faces . It is revealed that the decrease in the current of thePhDt under illumination B (III) of the face always exceeds A (III) faces. The observed phenomenon can be explained as follows.

Since, p3- is the bonds of atoms of the III group, with which the gallium A (III) ends, the crystal face should deviate from the main direction of the p3 – bonds in the semiconductor, striving to carry out the trigonal configuration existing in crystals of the III group, which leads to a deformed compression [5] of this face. In the case of a p3 -bonds of the V group, the pyramidal configuration deviates from the p3- connection, i.e. links to B (III) are relatively stretched. Consequently, due to the difference in the structure of A (III) and B (III) faces, the microhardness of the GaP surfaces being studied differs from each other, as a result of which, with the same mechanical treatment, broken layers of different thickness are formed (Fig. 2).

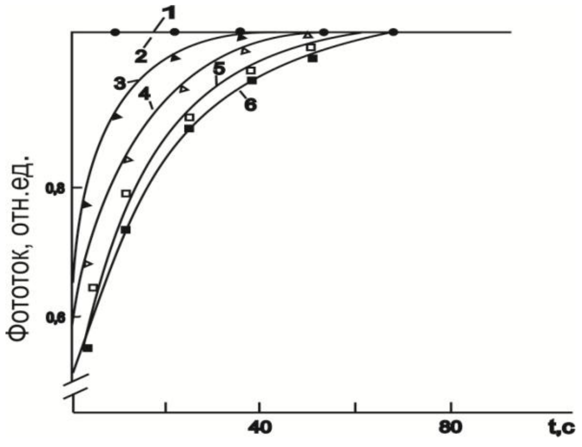

Fig.2.The change in photocurrent of PhDtdepending on the time of etching the GaP crystal with different processing methods and orientation of the illuminated surface: 1, 2 smooth polished surfaces of A (III) and B (III) faces, for these surfaces during machining with abrasive powder M5 and M14, respectively

III. CONCLUSION

Thus , strengthening the anisotropy effect of T (λ) during the machining of polar A (III) and B (III) faces of GaP is due to the correlation between the magnitude of T (λ) and the thickness of the damaged near-surface layer.

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