Features Of Obtaining Gallium Arsenide Semiconductor Structures With Microtextured Surface

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***Abstract*—On the basis of a substrate of gallium arsenide single crystal by chemical anisotropic etching, textured microrelief surfaces are formed and subsequent diffusion of Zn and epitaxial growth from the liquid phase, photosensitive structures n^+GaAs-nGaAs (buffer) -pGaAs (diff. layer) -pAlGaAs (epit. layer) are made with a microrelief interface, in which close to traditional values of open circuit voltage (0.5–0.7 V) and short circuit currents (6-12 mA/cm^{-2}) were obtained.**

Keywords—single-crystal, gallium arsenide, photosensitive, microrelief, currents of short circuit.

1. Introduction

Currently, more attention is paid to the development of gallium arsenide multilayer photosensitive structures with improved functional characteristics [1,2]. In this case, the study of the relationship of their operational parameters with the electrophysical parameters of the active region will allow us to obtain new technical solutions that contribute to the disclosure of previously unknown capabilities of multilayer photosensitive structures. Compared with the photolithography technology of forming cells on the surface of photodetector structures in the form of honeycombs and pyramids [3-5], methods for producing textured surfaces by anisotropic etching can also be of interest.

This paper presents the results of the study of microstructured textures and photosensitive multilayer structures based on them.

2. Experimental results and their discussion

In the structures under study, the required textures were first obtained on the surface of the substrate, and then frontal regions of photosensitive structures were obtained from the oxide phase by diffusion or epitaxial growth. On the surface of single-crystal GaAs oriented in the (100) crystallographic direction by anisotropic etching [6], two types of microrelief morphology promising for use in photoconverters were obtained: dendritic, obtained by etching a single crystal in concentrated HNO_3 acid, and a quasilattice type (system oriented along the direction (110) V-shaped grooves with a repetition period varying over the surface within certain limits) created by etching a single crystal in a mixture of 2HF: $2H_2SO_4$: $1H_2O_2$. Of the two types of morphology of the microrelief (dendritic and quasilattice) obtained by chemical anisotropic etching (100) of the *n*-GaAs surface, the quasi-lattice microrelief is more promising for use in structures with a Schottky barrier, especially for space purposes, since it allows one to obtain a large efficiency and radiation resistance in comparison with a flat analog.

To develop methods for the growth of epitaxial layers, we [7] technologically obtained a new surface modification in the form of protrusions - as a volume hexagon, as well as in the form of a microrelief on the surface, and without destroying the surface of the semiconductor, i.e., by controlling the components of the solution melt and epitaxy regimen. The developed technology for growing a microtextured surface by liquid epitaxy based on indium and aluminum containing epitaxial layers of gallium arsenide on gallium arsenide substrates makes it possible to increase the angle of capture of absorbed light radiation by the surface in comparison with a flat structure (up to 90 angular degrees versus 50 degrees in flat structures).

The difference between the active regions is that the interface of the photo-separating *p-n* junction and the front layer, as can be seen from (Fig. 1), has a wavy shape.

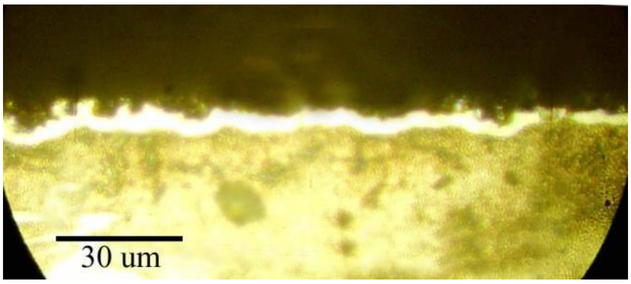


Fig. 1. Micrograph of the border

section of the diffusion microrelief *p-n* junction. V_{ocv} = 0.7, I_{scc}, = 6.0 mA

This means that its length is greater than if a flat junction were created, Fig. 2. Accordingly, a photoconverter with a flat surface with a given length of the *p-n* junction would have a large area by a difference value.

Fig. 2. Micrograph of cleaved structure

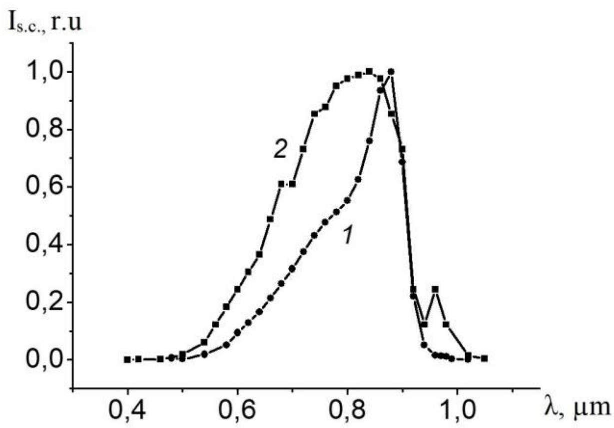
with flat *p-n* junction

Microrelief *p-n* junctions can save the substrate material by the amount of compression or, in the case of diode structures, to produce them with a smaller area. Here, we can say that we have savings (more than 10%) when efforts are made by units of percent.

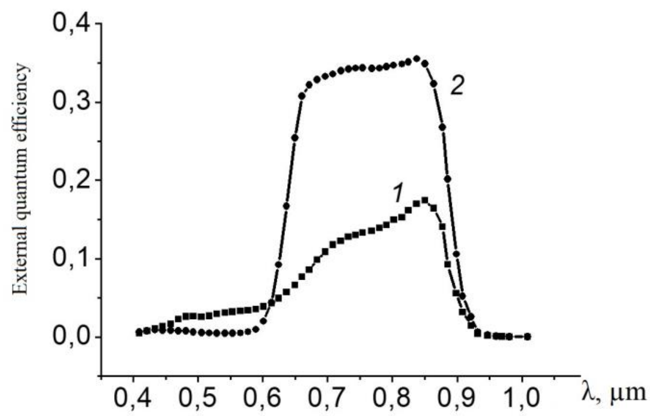
In addition, due to the difference in the electrophysical and optical properties of the active region, not only the photoconverter, but also any semiconductor structure (diode, transistor, etc.) made using this technology acquires new properties. From these points of view, structures with a bulk microrelief *p-n* junction are promising. In particular, in terms of resistance to radiation and light radiation and other properties.

In the multilayer structures under study, frontal *p*-type epitaxial layers with a thickness of 0.5 μm were grown from a Ga-melt solution (1.12 g.) + *p*GaAs (0.18 g.) with a charge carrier concentration of $7.5 \cdot 10^{17}$ cm^{-3}, in the temperature range from 848°C to 845°C at a constant cooling rate of 1deg/min, and *n*-type conductivity layers 1 μm thick were grown from a solution-melt Ga (1.12 g) + *n*GaAs (0.18 g) with a source with a carrier concentration of $1 \cdot 10^{16}$ cm^{-3}, at initial temperature of 845°C, and the solution was cooled at a decreasing speed from 3 deg/min to 0.5 deg/min. In accordance with the selected dopant and the growth rate of the epitaxial layer from the liquid phase, an appropriate profile of the distribution of impurities over its thickness will be formed.

It has been experimentally shown that in the obtained multilayer photovoltaic structure with a microrelief surface, the region of spectral sensitivity expands into the short-wavelength part, and the quantum yield becomes twice as large compared to structures with a flat surface (Fig. 3), which makes it possible to use such a structure purposefully in as a photovoltaic receiver. The detecting effect is associated with an increase in the photosensitive area at the *p-n* junction boundary during the formation of microreliefs.



a) spectral response



b) external quantum efficiency

Fig. 3. Photoelectric characteristics of structures with a flat (1) and microrelief (2) *p-n* junction

3. Conclusion

In summary, on the basis of a substrate of gallium arsenide single crystal by chemical anisotropic etching, textured microrelief surfaces are formed and subsequent diffusion of Zn and epitaxial growth from the liquid phase, photosensitive structures n^+GaAs-*n*GaAs (buffer) -*p*GaAs (diff. layer) -*p*AlGaAs (epit. layer) are made with a microrelief interface, in which close to traditional values of open circuit voltage (0.5–0.7 V) and short circuit currents (6-12 mA/cm^{-2}) were obtained respectively.

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