Optical and Acoustical Methods in Science and Technology

Transverse Acoustoelectric Effect Applying in Surface Study of GaP:Te(111)

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The possibility of using the transverse acoustoelectric phenomena in experimental investigations of near surface region in semiconductor crystals was discussed. The results of experimental investigations of GaP:Te(111) surfaces by means of the transverse acoustoelectric voltage were presented. Applying the transverse acoustoelectric voltage method, the lifetime τ of minority carrier in the near-surface region and the surface potential V_s in GaP:Te(111) surfaces after their different technological treatments were determined.

PACS numbers: 72.80.Ey, 73.61.Ey, 73.61.Jc, 85.30.−z, 71.20.Mq

1. Introduction

Gallium phosphide GaP surfaces are still the interesting objects for studies due to the large application of this semiconductor in production of the optoelectronics devices, such as ionizing radiation detectors, light sources and infrared photodiodes. The aim of our work was to determine the effective lifetime (τ) of minority carriers in the near-surface region and the surface potential for GaP:Te(111) surfaces [1–5]. The investigations were performed by means of the transverse acoustoelectric voltage (TAV) method after various technological treatments of the surfaces of the single crystals GaP:Te(111) [4–8].

All properties of the surface of semiconductor single crystals strongly influence electronic processes occurring at surfaces and interfaces of semiconductors [6–12].

It should be mentioned that up to now there are restricted number of works which have been devoted to studies of the "real" GaP surfaces [1, 3, 5, 9]. The real surface of semiconductor means the surface obtained after cutting, polishing and standard chemical etching of the crystal. The real surfaces appear at various introductory steps of the semiconductor device technology.

2. Experimental procedure

The measurements of the acoustoelectric effect were performed for the (111) surfaces of GaP:Te with the donor concentration of 3×10^{14} cm^{-3} and the electrical bulk conductivity $\rho = 110$ Ω cm.

Before the TAV measurements the samples were submitted to the following technological procedures:

1. mechanical grinding and polishing with an alumina powder and diamond paste and then cleaning in benzene and deionized water,
2. etching in HF and cleaning in deionized water,
3. long lasting rinsing in deionized water.

The measurements of TAV were carried out for a 226 MHz frequency of the surface acoustic wave.

The details of the experimental setup for the TAV measurements were presented in [6, 8, 10].

3. Results and discussion

Figure 1 shows the time dependence of τ obtained for surfaces of GaP:Te(111) after their different technological treatments. All investigated samples were prepared from the same piece of the semiconductor GaP:Te single crystal.

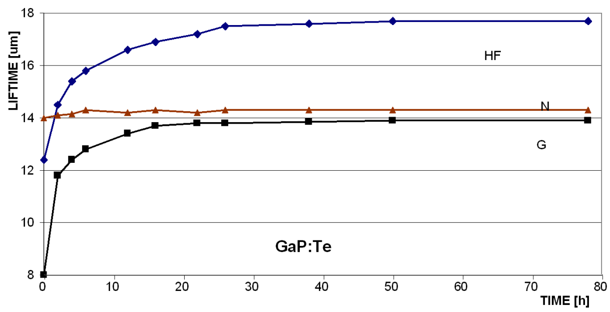

Fig. 1. The time dependence of lifetime τ for GaP(111) surface after different treatments: HF — etching in HF; G — mechanical grinding of an alumina powder 150; N — long lasting rinsing (≈ 20 h) in deionized water.

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The method of determining the value of τ from TAV measurements is described in detail in [3, 9].

From Fig. 1 one can see that the change of τ vs. time depends strongly on the type of the used surface treatment.

For example, after the etching of GaP by HF acid the value of lifetime τ grows up nearly twice and the study stated τ value is obtained during 15 h. The long-lasting rising of the GaP sample in deionized water changes its life time unnoticeably.

Moreover, the transverse acoustoelectric effect allowed to determine the value of the surface potential V_{s} on the base of common applications of the theoretical and experimental dependences of TAV (U_{AE}) vs. the external electric field (practically — electric voltage U_{d}), on the direction perpendicular to the investigated surface [3, 6].

The experimental dependence of U_{AE} vs. U_{d}, obtained for the GaP:Te surface etched in HF, is shown in Fig. 2.

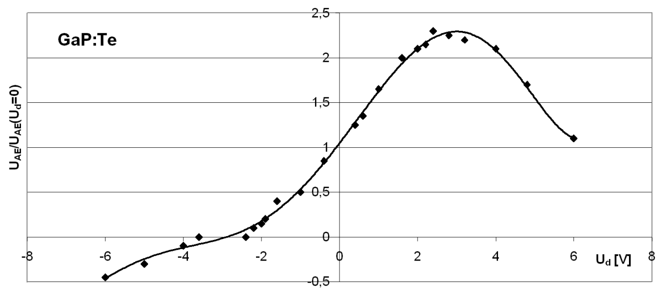

Fig. 2. Experimental dependence of the transverse acoustoelectric voltage U_{AE} on external voltage U_{d} for GaP(111) surface.

In this case V_{s} is equal to -0.33 V, which means that the depletion layer near the surface of the n-type GaP:Te (111) existed.

The values of the surface potential obtained by the acoustic method are similar to the values obtained by El-Dessouki [5].

The control of the influence of the methods of the semiconductor surface treatments on the values of surface parameters are very important for future applications of single crystals in production of electronic and optoelectronic devices [9–12].

The main advantage of the TAV method is the possibility of determining the values of the surface semiconductor parameters in high frequency range [3, 4, 7, 11].

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