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TEXTURING OF THE INDIUM PHOSPHIDE SURFACE

***Y.A. Suchikova*[1], *V.V. Kidalov*[1], *O.S. Balan*[1], *G.A. Sukach*[2]**

[1] Berdyansk State Pedagogical University,
4, Shmidta Str., 71100, Berdyansk, Ukraine
E-mail: V.V.Kidalov@mail.ru

[2] V. Lashkaryov`s Institute of Semiconductor Physics NASU,
41, Nauky Av., 03028, Kiev, Ukraine

In this work the photoelectrochemical method for texturing the monocrystal InP surface is proposed. By means of the scanning electron microscopy the optimal formation conditions of the samples with developed morphology and uniform cluster distribution over InP surface are established.

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1. INTRODUCTION

Needs of modern society in processing and transfer of the growing information content leaded to the formation of the super-high-speed optoelectronic integrated circuits based on silicon and binary semiconductors. Integration of transistor structures into very large-scale integrated circuits is technologically limited by the physical boundaries of the microregion size and the low charge mobility in semiconductors. The solution of this problem is in the increase in the functionality of the elements [1-3]. At present, gallium arsenide, indium phosphide and zinc selenide are the most technically perfect after silicon. And namely indium phosphide occupies a special place among these semiconductors.

Indium phosphide (InP) has great prospects of wide industrial production. Field-effect transistors and other microwave devices are manufactured based on InP. Monocrystalline InP plates are used as substrates for the growth of different heterostructures, which are the basis of effective radiation sources (injection lasers, light-emitting diodes) and high-speed photodetectors for the systems of fiber optic communication lines. InP is promising for the development of super-high-speed integrated circuits. Presently InP is the most probable material for the mass production of integrated circuits. It is impossible not to mention about the growing interest in porous InP, which has unusual optical and electrical properties in comparison with the monocrystalline InP. A lot of scientists [4-7] devoted their attention to this question. However the porous structure formation is only possible under the condition of *n*-type semiconductor use. This paper is dedicated to the problem of the increase in *p*-InP effective area that is realized by the surface texturing method, which becomes more and more popular among scientists and engineers. Such structures can find application in sensor (since their sensitivity depends on the surface area) and solar cell (possibility of the accumulation of a record amount of energy) manufacturing. At present, it is considered that to obtain a textured surface with the specified properties, the ion and plasma chemical etching methods, laser treatment together with lithography should be used. But these methods are technologically difficult, in addition they substantially increase the cost of manufactured structures and therefore they are uneconomic.

Obtaining of *p*-type InP textured layer by the photoelectrochemical etching method, which is quite simple and does not need special equipment, is the basis of the present investigation. Image of the surface obtained using the scanning electron microscope (JSM-6490) is the proof of the appearance of textured structures.

2. EXPERIMENTAL PART

For the experiment we chose the samples of monocrystalline *p*-InP with the carrier concentration of $2{,}3 \times 10^{18}$ cm^{-3}. Solutions of etching, bromide and hydrochloric acids were used as the electrolyte. The current density varied in the range from 30 to 180 mA/cm^2, the etching time was 5-30 min. Before the experiment samples were purified in acetone and methanol, washed in distilled water and dried in nitrogen. After drying the texturing of monocrystalline InP plates in anisotropic etchants with different etching rate on different monocrystalline faces was performed. During the etching of plates the regime of sample illumination by the tungsten lamp of the power from 20 to 250 W was used. The sample was submerged in the acid solution. As the cathode in electrochemical cell we used a platinum plate. Potentiostate was used for the adjustment of the current density and/or anodization voltage.

3. RESULTS AND DISCUSSION

The essence of the method is in the following. While submerging the semiconductor InP plate in the etchant solution, its molecules are adsorbed on the plate surface. With direct current passing through the electrolyte adsorbed molecules detach from the surface of the plate. In this case the phosphorus atoms adsorb easier with the hydrogen ions that provides faster etching of the phosphorus sublattice. Stoichiometry of the sample is violated towards the increase in the concentration of indium atoms. As a result the set of pyramidal clusters is formed on the plate surface. Slope of the cluster edges provides the obtaining of a rather low reflection coefficient and the tenfold increase in the active area of the plate in comparison with the monocrystalline sample.

The optimal concentration of the electrolyte, current density and etching time were established experimentally in order to obtain the most uniform in the height and shape texture. Thus, the optimal conditions for the obtaining of qualitative texturing *p*-InP surface are given below: the etchant composition is $HBr{:}H_2O = 1{:}1$; the current density is 150 mA/cm^2; the etching time is 8 minutes; the power of the tungsten lamp is 200 W.

Fig. 1 demonstrates the morphology of the textured InP plate. As seen from this figure, the dense system of pyramidal growths with the slope connected with the crystal anisotropy and current direction is formed on the monocrystal surface. The pyramid height varies from 0,7 to 1,1 μm. Under the assumption that the abovementioned conditions are not executed the semiconductor behavior during the anodization has some peculiarities. Thus, with the increase in the etching time up to 15 min the pore grooves start to grow deep into the substrate that is accompanied by the plate surface failure. While etching less than 8 min the incomplete surface texturing is observed, i.e., some surface regions stay with the conserved monocrystallinity and surface orientation.

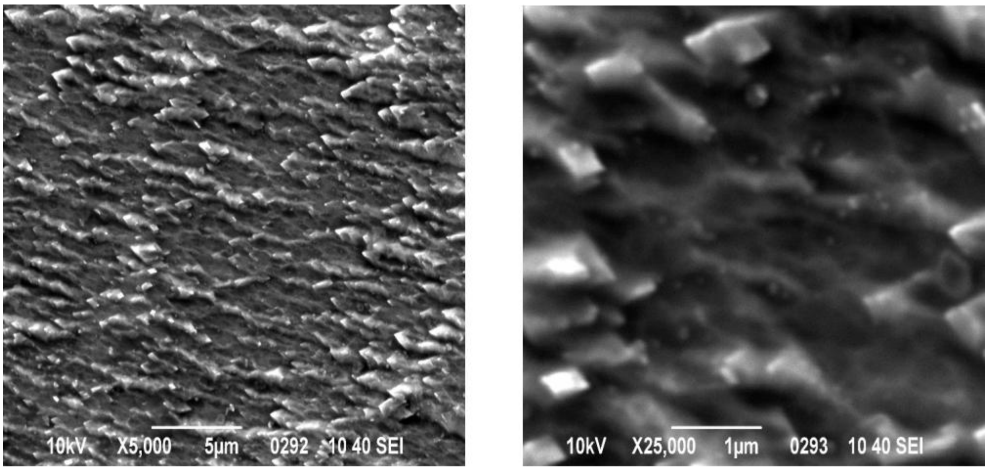

Fig. 1 *–* *p*-InP *textured structure*

If the current density is more than 150-170 mA/cm^2 the etching of InP layer of the thickness of about 8-10 μm is observed. At current densities less than the mentioned values the pyramids have insufficiently pronounced shape and height (less than 0,5 μm). At higher acid concentrations in the electrolyte solution the insoluble films composed of the adsorbed by the semiconductor surface bromine atoms are formed. At low acid concentrations the figure formation on the InP surface does not take place at all. Illumination of the plates is the necessary condition as well. This provides high density of the pyramid distribution over the surface of the sample (density is about 5 pyramids per 1 μm). We have to note that solutions of other acids also do not provide sufficient level of the surface texturing. Moreover, *n*-InP monocrystals demonstrate an inability to texturing. The fact is that while anodizing in the acid solutions the plates with the electron conductivity are easily etched forming the porous layers.

4. CONCLUSIONS

In the present work the texturing method of the monocrystal *p*-InP surface is proposed. This method is technically simple, cheap reagents are used for its realization, it does not need special equipment and therefore it is economic one. We also established the optimal formation conditions for the samples with developed morphology and uniform cluster distribution over the sample surface.

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