Obtaining and research of properties of porous GaAs

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***Abstract*— Porous GaAs layers have been produced by electrochemical anodic etching of n-GaAs. The results of researches of optical characteristics of low sized structures of porous gallium arsenide have been considered. The calculation of width of band gap of porous gallium arsenide with the help of measurements of spectra of photo-emf has been made. The have been analyzed spectra of photoluminescence obtained porous compounds.**

***Index Terms*— porous gallium arsenide, photo-emf, spectra of photoluminescence**

I. INTRODUCTION

In the last decade more attention is paid to the problem of getting of porous semiconductors. Some result in study of optical and electronic properties have been got in experiments with using of porous layers Si, Ge, GaAs, SiC, GaP, InP and others.

Optical and electronic properties of porous semiconductors, according to effect of size quantization are differed from the same properties of monocrystalline structure and depend on the size of nanoparticles. Managing by size of particles it is possible to manage by optical and electric properties of lawsized structures. The dependence of properties of semiconductors from sizes of pores and nanocryslals has been defined in the first experiments.

The most accessible method of getting of porous layers of semiconductors A_3B_5 group is the method of electrochemical etching. In work [1] porous GaAs layers have been produced by electrochemical anodic etching of (100) heavily doped p-type GaAs substrate in HF solution.

In work [2] morphology and electrical properties of porous silicon have been investigated 20, 25 and 30 mA/cm^2 at 30 min.

The differences consist not only in the composition of the spent electrolyte. The meanings of position of maximum of PL spectrum of porous layer are also contradictory. In researches there were noticed the shift of maximum of radiation of porous GaAs in short wavelength region. This phenomenon is determined by the quantum size effects in the por-GaAs. The energy of electrons and holes is quantized because of reduction of particles to nanosizes, so the width of band gap in semiconductor of nanocrystals is increased [3].

The Measurements and calculations meaning the width of prohibited zone of semiconductors are widely used at study of their fundamental characteristics.

There are many methods for determining the width of the band gap of semiconductor: the method which is based on the measurement of the spectral dependence of light absorption [4], the method which is based on the analysis of edge luminescence spectra [5], the method which is based on the approximation of the straight line of growth of the main maximum in the long-wavelength part of the spectrum to the intersection of this line with coordinate axis along which delayed photon energy [6].

The work describes a method of getting of porous layer by means of electrolytic anodic etching of n-GaAs. There have been made the comparative calculations of meaning of width of band gap of getting layer of por-GaAs.

II. PROCEDURE FOR PAPER SUBMISSION

We study the porous structure of semiconductor GaAs (001) n-type of conductivity. The porous surface has been got by means of anodic electrochemical etching in Teflon cell. As a cathode there were used a plate of platinum. The samples were polished and degreased with ethanol, followed by washing in distilled water before each experiment. At the end of the stage of preparation the samples were dried in a stream of N_2. Further, a part of the sample and platinum connected to power source, immersed in electrolyte. The current densities ranged from 30 to 270 mA/cm^2. As electrolytes were used aqua HF:C_2H_5OH=2:1, HF:C_2H_5OH=1:1, HF:C_2H_5OH=1:2 during the time period from 2 to 15 minutes.

The surface of the sample was washed with ethanol and distilled water at the end of electrochemical machining. Then samples were dried in a stream of atomic nitrogen. All experiments were executed at room temperature. The resulting samples were examined with a scanning electron microscope JSM-6490.

The electrolyte aqua is selected so as to get maximum penetration depth and the minimum pore size. The most favorable results were got by using electrolyte consisting of ethyl alcohol C_2H_5OH and hydrofluoric acid HF in correlation 1:1.

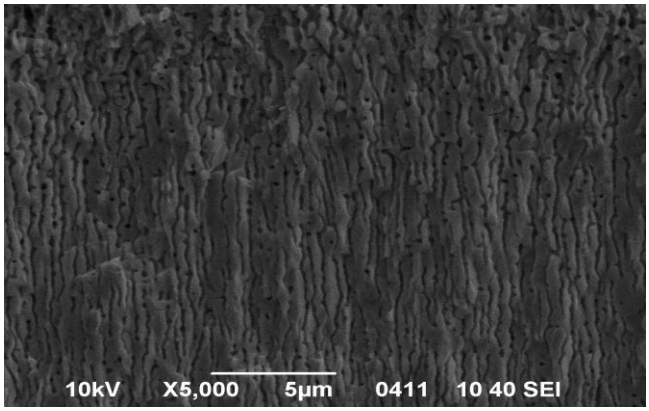

Fig. 1. The SEM image of cross section of porous sample n-GaAs (001) got by means of anodic electrochemical etching, the current density is 180 mA/cm^2, the etching time is 10 min.

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At fig. 1 there is a micrograph of cross sectional of porous sample GaAs, got by means of anodic electrochemical etching. Obviously, the anodizing leads to forming of pores penetrating from the surface into the semiconductor.

The pore size was in average 100 nm.

III. The results of experiment

At fig. 2 shows the spectrum of photoluminescence (PL) of got structure. As shown at this figure, the displacement of the main PL takes place. The PL spectrum of got structures is a symmetrical band with maximum at 870 nm. The shift of the main PL band occurs in shorter wavelengths. This phenomenon can be explained by quantum size effect (reduction in pore size of porous GaAs quantum will increase the gap between quantum levels and offset baseband PL). The spectrum of resulting structure, in compare with PL GaAs spectrum, significantly expanded. The maximum of its emission band is shifted towards, the peak of PL band is located near the energy about 1,8 eV (690 nm).

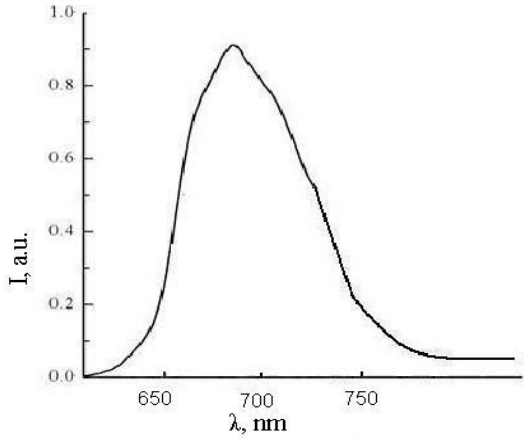

Fig. 2. The photoluminescence spectrum of porous GaAs.

There have been made the calculation of band gap of porous GaAs by measuring spectra of the photo-emf.

The measurement of spectra photo-emf was realized with the help of pulsed light samples with number of incident photons 10^{12} cm^{-2} h-long waves λ_M = 0,5-1,0 mm.

For calculations of width of prohibited zone of porous gallium arsenide were used spectra of photo-emf at relevant wavelengths. According to obtained spectra the width of band gap was 1,77 eV (700 nm).

To verify the correctness of calculations there were compared results of determining the width of band gap in the spectral dependence and the spectrum analysis of the main band PL of porous GaAs. The difference between the obtained values was 0,03 eV (10 nm).

IV. Conclusion

The calculation of the width of band gap of porous arsenide gallium got by means of method of electrochemical etching on the measurement of the spectra of photo-emf has been made. There have been analyzed the photoluminescence spectra of porous compounds. To verify the correctness of calculations there have been compared results of determining the width of band gap of porous GaAs by two methods.

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