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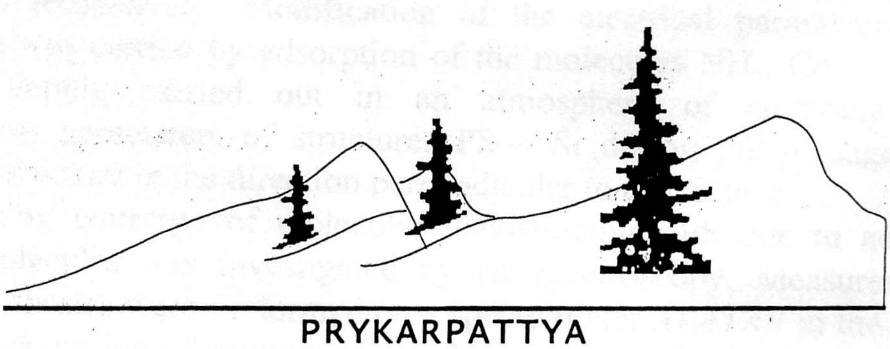
ACTUAL PROBLEMS OF SEMICONDUCTOR PHYSICS

ABSTRACT BOOK



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INFLUENCE OF AMMONIA ADSORPTION ON ELECTRICAL AND PHOTOELECTRICAL PROPERTIES OF THE POROUS SILICON – SILICON STRUCTURES

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Porous silicon (PS) reveals a number of unique properties caused by its sponge-like geometrical structure. Owing to an increased bandgap, antireflective properties and a large surface area per unit volume, silicon nanostructures are promising for photoelectronics and sensor electronics [1,2]. A common feature of most gas adsorption sensors based on the PS is usage of adsorption-induced electrical effects that cause substantial changes in the free charge carrier concentrations of the PS and its electrophysical parameters such as electrical conductivity or capacitance.

Other side, controlled adsorption chemically active or polar molecules can target modified electrical parameters nanostructures of silicon. Observed transformation of hole-type conductivity of mesoporous silicon into electronic conductivity (see the case of adsorption of NH_3 molecules that exhibit donor properties [3]), or electronic-to-hole conductivity inversion (the case of adsorption of I_2 or Br_2 molecules revealing acceptor properties [4,5]). Nonetheless, applications of adsorption-based techniques for controlling the conductivity type have still not received sufficient attention from researchers. This can be caused by inversion of the conductivity type occurring in nanocrystals of the porous layer.

We studied possibility to control conductivity type nanocrystals of PS by adsorption of ammonia molecules. PS nanostructures were prepared on single-crystal substrates electronic and hole type conductivity with resistivity of 4.5 and 10 Ohm·cm respectively. Modification of the electrical parameters of silicon nanocrystals was carried by adsorption of the molecules NH_3. Control of process adsorption doping carried out in an atmosphere of ammonia measuring electrophysical parameters of structures PS – Si during the passage of current through the structure in the direction perpendicular to the surface.

Changing coverage of molecular nanostructures PS due to adsorption of ammonia molecules was investigated by IR spectroscopy. Measurement of IR transmission spectra were performed on a spectrometer *AVATAR* in the range 400 - 4000 cm^{-1}. Adsorption of ammonia caused appearance of new absorption bands in the spectral region 1250 - 1300 cm^{-1}, which probably related to oxygen- and nitrogencontaining complexes. Also was observed some redistribution of the intensity of shoulder bands, which proves the transformation component of the porous layer.

Our studies reveal that the adsorption of ammonia molecules significantly affects the electrical conductivity of the 'PS-silicon substrate'. The natures of conductivity changes occurring in the PS – *n*-Si and PS – *p*-Si structures turn out to be different. An increase in the conductivity of PS – *n*-Si nanostructures is observed with increasing ammonia concentration. Apart from a decrease in the conductivity PS – *p*-Si observed with an increasing NH_3 concentration, one can see a 'rectification effect' inherent to *p-n*-junctions. Notice that the direct branch of the CVC corresponds in this case to the negative potential at the porous layer. This can be caused by inversion of the conductivity type occurring in nanocrystals of the porous layer and appearance of photosensitive electrical barriers on the edge of PS – silicon substrate.

For obtaining additional information about the nature of influence of the NH_3 adsorption on photoelectrical properties of the PS – *p*-Si we have investigated spectral dependences of the photoresponse in that structure. The photovoltage spectra of adsorptionally modified samples at open circuit regime were similar to the photoresponse spectrum of industrial silicon photodiode and were characterized by the wide maximum in the 750 ÷ 950 nm range.

Thus it has been shown that adsorption of ammonia molecules modifies the electrical properties of 'PS-silicon substrate' structures. The obtained data suggest the possibility of controlling the conductivity type of PS nanocrystals by adsorption of chemically active or polar molecules. The structures based on adsorptionally modified PS demonstrated the photovoltaic effect in the visible spectral range what extends the prospects of their use as photodetectors. The obtained experimental results can be also used for the development of electronic devices not only based on porous silicon, but also on systems of semiconductor nanocrystals.

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