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Morphology, luminescence, and electrical resistance response to H_2 and CO gas exposure of porous InP membranes prepared by electrochemistry in a neutral electrolyte

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ABSTRACT

Porous InP membranes have been prepared by anodization of InP wafers with electron concentration of 1×10^{17} cm^{-3} and 1×10^{18} cm^{-3} in a neutral NaCl electrolyte. The internal surfaces of pores in some membranes were modified by electrochemical deposition of gold in a pulsed voltage regime. Photoluminescence and photosensitivity measurements indicate efficient light trapping and porous surface passivation. The photoluminescence and electrical resistivity of the membranes are sensitive to the adsorption of H_2 and CO gas molecules. These properties are also influenced by the deposition of Au nanoparticles inside the pores.

1. Introduction

Porous semiconductors are attractive for many optoelectronic and photonic applications [1,2]. Due to a large internal surface area, porous semiconductors present interest for the development of photoelectrochemical solar cells [3] and gas sensors [1,4]. Porous III–V compounds also exhibit new properties [7] with a large potential for applications. These properties depend in a great extent on the state of the porous skeleton internal surface. Previous investigations showed that electrical and optical characteristics of porous semiconductors may change considerably as a result of adsorption of molecules to their surfaces and/or by filling the pores [6–9].

An advantage of porous III–V semiconductors as compared to porous silicon is their wider composition diversity, and, respectively, more possibilities for surface engineering which are very important, particularly, for the elaboration of photoelectrochemical solar cells and gas sensors [3,4]. Recently, possibilities for controllable porosification of III–V substrates by anodic etching in an environmentally-friendly neutral electrolyte based on aqueous solution of NaCl instead of aggressive acids or alkaline electrolytes have been demonstrated [10–12], which is also an advantage.

In this work, we report on morphology, photoluminescence, photosensitivity, and electrical resistivity characteristics of porous InP membranes prepared by anodic etching in a neutral electrolyte. The influence of catalytic activation by Au nanoparticles, and gas adsorption upon these properties is also discussed.

2. Experimental details

InP with 500 μm thickness and free electron concentrations of 1×10^{17} cm^{-3} and 1×10^{18} cm^{-3} were used. The samples were supplied by CrysTec GmbH, Germany. Anodic etching was carried out in dark at room temperature in NaCl aqueous solution in potentiostatic regime in an electrochemical double cell as described elsewhere [13], the sample being mounted between the cells. The area of the sample exposed to the electrolyte was 0.25 cm^2. The electrolyte was pumped through both cells in a continuous mode. A four-electrode configuration was used: A Pt reference electrode in the electrolyte, a Pt sense electrode on the sample, a Pt counter electrode, and a Pt working electrode. After growth of pores, a shock voltage was applied for a few seconds to detach the porous layer from the substrate. The top nucleation layer of samples was removed by isotropic wet etching. Subsequently, the samples were

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