Optical and Photoelectrical Properties of Electrochemically Nanostructured III-V Compounds

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Compared with porous Si, electrochemically-nanostructured III-V materials have a number of important advantages including the potential for changing the chemical composition and further extending the applications of porous structures using properties specific to acentricity.

In this work, porous layers and free-standing membranes of III-V compounds such as GaP, GaAs and InP have been fabricated and characterized by scanning electron microscopy (SEM), photoconductivity (PC), micro-cathodoluminescence (CL), optical transmission and optical second harmonic generation (SEG) techniques.

Electrochemical nanostructuring is shown to sharply increase the efficiency of SHG [1] and to induce an artificial birefringence necessary for phase matching. The artificial anisotropy induced by nanotexturization was studied in optically homogeneous porous membranes and the refractive indices for ordinary and extraordinary beams were evaluated. Optimization of the shape of pores and air fill factor allowed one to provide material percolation and at the same time to reach maximum effective second-order susceptibilities and as high degrees of porosity as to fulfill the phase matching conditions. The nature of the porosity-enhanced nonlinear optical response in III-V compounds is discussed.

Synchronous spatial modulation of porosity and CL intensity was achieved in GaP [2] and InP by varying the anodization conditions. Surprisingly, the higher the degree of porosity of GaP the stronger the intensity of CL. In InP, on the contrary, porosity proves to play the role of killer of luminescence. Fig. 1 illustrates synchronous modulation of the degree of porosity and CL intensity in porous InP.

Electrical transport in free-standing membranes of III-V compounds subjected to nanotexturization proves to be governed by potential barriers caused by the overlapped surface depletion layers related to neighboring pores. The photosensitivity of porous structures was found to be by a factor of ten higher in comparison with that of bulk single crystals. We present the results of a systematic study of the kinetics of photoconductivity in porous III-V compounds as a function of the conditions of excitation (wavelength of the electromagnetic radiation, excitation power density) and sample temperature. The phenomenon of persistent photoconductivity (PPC) was observed and studied in porous GaP and InP membranes (see Fig. 2). Based on the obtained results, we show that porous III-V structures are promising for the elaboration of nonlinear optical elements, optical filters, Bragg reflectors, micro-lasers, optoelectronic memory devices and switches which could be easily integrated into optoelectronic circuits.

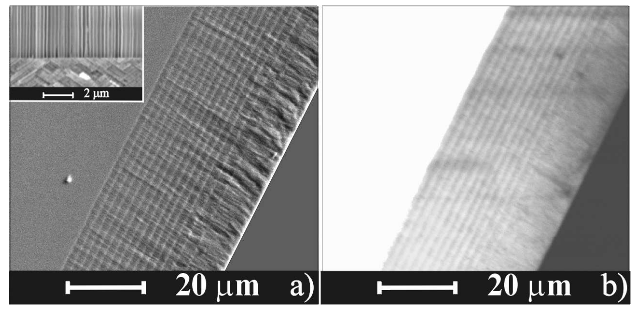

Figure 1. a) SEM and b) panchromatic CL images in cross section taken from a porous InP structure with spatially modulated degree of porosity. The insert shows the interface between two neighbouring porous layers.

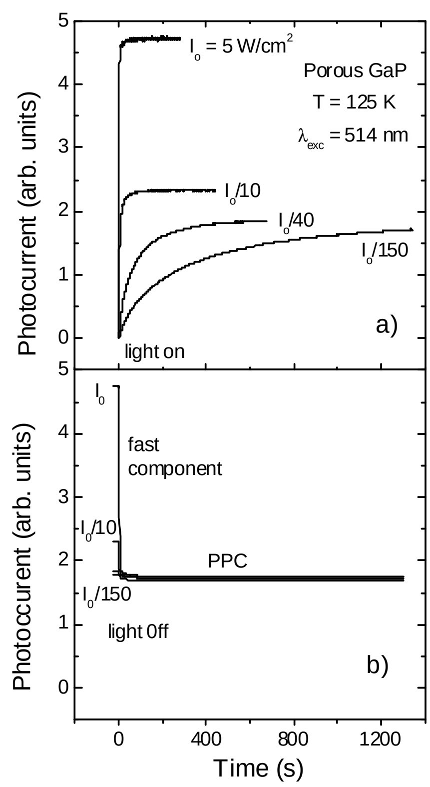

Figure 2. PC transient in a porous GaP membrane at different light intensities and T = 125 K. a) light on; b) light off.

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