Properties of 2D and 3D Dielectric Structures Fabricated by Electrochemical Dissolution of III-V Compounds

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ABSTRACT

Porous layers and membranes representing 2D and 3D dielectric structures were fabricated on different III-V compounds (GaAs, InP, GaP) by electrochemical etching techniques. Nonlithographically fabricated ordered nanopore arrays in InP are reported for the first time. We show that the reflectance from nanostructured InP is lower than that from bulk InP in the spectral interval 1.5-2.2 eV. The artificial anisotropy induced by nanotexturization was studied in porous GaP membranes and the refractive indices for ordinary and extraordinary beams were evaluated.

INTRODUCTION

Electrochemistry proves to be a powerful tool for producing dielectric structures on solid-state materials. The fabrication of polycrystalline nanopore arrays with hexagonal ordering by self-organized anodization on aluminum has already been reported, e.g. [1]. The mechanical stress associated with the expansion of the aluminum during oxide formation was suggested to generate repulsive forces between neighboring pores during the oxidation process leading to self-organized formation of hexagonal pore arrays [2]. Ordered pore arrays on large areas can be prepared using prepattern-guided anodization of both aluminum and crystalline silicon [3,4]. Recently the electrochemical etching techniques were used to fabricate semiconductor sieves of gallium phosphide, i.e., two-dimensionally nanostructured membranes exhibiting a strongly-enhanced optical second harmonic generation in comparison with the bulk material [5]. Moreover, crossing pores were observed in GaAs indicating that anodic etching may be a suitable and unique tool for the production of 3D micro- and nanostructured III-V compounds [6]. In this work, we explore the possibility to produce quasi-periodic dielectric structures on III-V compounds by electrochemical etching techniques. Data concerning morphology studies and optical characterization of samples are presented.

EXPERIMENTAL

N-type (100) oriented InP, GaAs and (111)-oriented GaP wafers cut from Czochralski grown ingots were used in this work. The free carrier concentration was $n = 10^{18}$ cm^{-3} at 300 K. The anodization was carried out in an electrochemical double cell as described elsewhere [6] in HCl and H_2SO_4 aqueous electrolytes. The area of the sample exposed to the electrolyte was 0.2 cm^2. The supply of holes was due to the reverse bias applied to the semiconductor/electrolyte junction, which involves the avalanche breakdown effects accompanied by generation of electron-hole pairs.