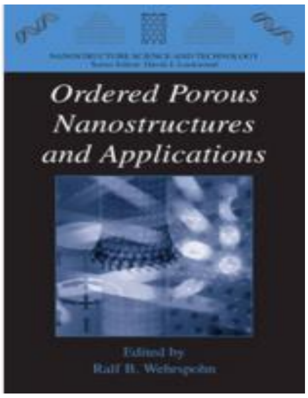

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The Way to Uniformity in Porous III–V Compounds via Self-Organization and Lithography Patterning

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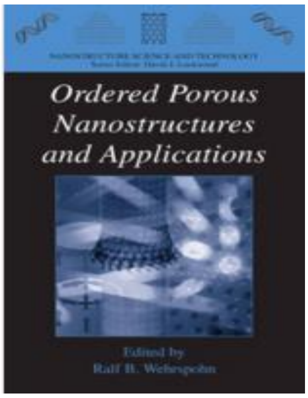
Abstract

Electrochemical etching techniques offer wide possibilities for modifying the surface morphology of semiconductors. Depending on the substrate type, electrolyte, illumination, etc., anodic etching may lead to both the electropolishing and the formation of pores. The factors determining the morphology of electrochemically etched III–V compounds have been reviewed by Gomes and Goossens as well as by Notten et al. [1,2]. Under anodic conditions the p- and n-type materials were found to behave quite differently. For instance, in the case of p-GaAs substrates in acidic solutions, the current in the anodic direction rises rapidly to very high values causing electropolishing of the material [3]. At the same time the n-GaAs/aqueous electrolyte interface shows diode characteristics. Under forward bias a cathodic current is observed, while under reverse bias the current measured in the dark is very low. In the case of n-type materials under anodic bias, the current limiting factor seems to be the space-charge layer at the semiconductor surface, i.e., the electron transfer at the interface is limited by tunnelling through the depletion layer or by carriers that overcome the barrier by thermal activation. As soon as a critical potential (the so-called pitting potential) is reached a steep current increase occurs leading to the formation of pits on the surface [4]. Current limitation via oxide film formation may also play a role although this issue has not been studied systematically so far [5]. Depending on the surface orientation and etching conditions, different types of porous morphologies have been observed in III–V compounds subjected to



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anodization, e.g., crystallographically oriented (CO) pores, current-line-oriented pores, tetrahedronlike pores, “catacomb”-like pores, etc. Electrochemical etching of a (111)A-oriented n-InP surface in a HCl/H_2O solution can lead to a top layer with a pillar structure characterized by quasi-isolated columns perpendicular to the initial surface [6]. A similar feature consisting of triangular-prism-shaped columns has also been revealed on (111)A-oriented n-GaP surfaces electrochemically etched in a solution of HF in ethanol [7]. In contrast, porous layers on n-GaP and n-GaAs surfaces with a (100) orientation show a cellular structure after etching in H_2SO_4/H_2O solution [7,8]. Moreover, in n-type (100)-oriented GaP after the initial pitting of the surface, further etching proceeds in directions both perpendicular and parallel to the surface. Since the extension of the porous structure occurs underneath the surface, this is termed a “catacomb”-like porosity.