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Account/Revue

Epitaxial growth on porous GaAs substrates

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ABSTRACT

We report on the electrochemical preparation of porous GaAs substrates in fluoride-iodide aqueous electrolytes for the lattice mismatched epitaxial growth from the vapor phase. The aim is to gain control over the uniformity of the pore nucleation layer and pore branching below this layer to achieve structures with a high degree of porosity and periodicity while leaving minimum damage on the substrate surface. Layers of $In_xGa_{1-x}As$ with varying In content are grown on GaAs substrates with different pore geometries and depths. Substantial differences in the surface morphology and photoluminescence efficiency of the layers grown on porous and conventional substrates are observed.

1. Introduction

A great deal of interest in localized dissolution and formation of porous semiconductors was triggered by the observation of efficient luminescence from porous silicon [1]. Recently, an increasing number of papers has been devoted to the preparation of porous III-V semiconductors [2–4] and their potential applications [5]. On the other hand, applications of porous substrates in heteroepitaxial growth are rare and investigations in this field are far from being systematic [6–8].

Epitaxial growth has always been a marriage of convenience between deposited layer and substrate. In the simplest case, both the layer and substrate are of the same material, providing a perfect homoepitaxial match. However, due to the existence of a limited number of substrates, which are available at acceptable quality and cost, restriction to homoepitaxial systems would greatly limit the number of applications. This limitation was the main driving force behind the progress of semiconductor epitaxial growth towards pseudomorphic, lattice mismatched heteroepitaxial systems, where small amount of strain is accommodated in very thin layers and multilayers. It was the development of vapor phase epitaxial techniques (molecular beam epitaxy and metalorganic vapor phase epitaxy) that allowed for the deposition of these systems with precise control and uniformity. Still, when the critical layer thickness is exceeded, misfit dislocations are created [9]. Dislocations greatly affect performance, reliability and lifetime of semiconductor devices [10,11]. A number of defect engineering approaches have emerged to gain control over the generation of defects during heteroepitaxial growth. Some of them intend to remove existing defects from lattice-relaxed layers (graded or superlattice buffer layers [12], epitaxial lateral overgrowth [13]), others try to avoid lattice relaxation by using reduced area growth and patterning [14,15], compliant substrates [16], or nanoheteroepitaxy [17,18].

A long time ago, it was proposed that porous substrates should be able to accommodate elastic strains generated at the heteroepitaxial interface of lattice mismatched materials during its formation and subsequent cooling [19].

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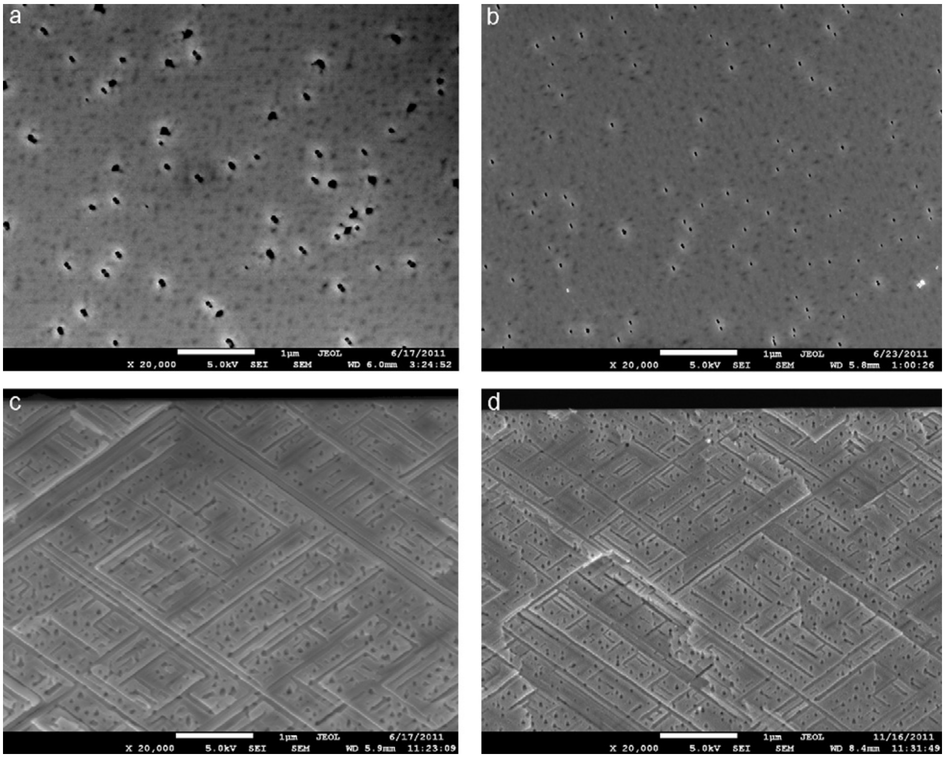

Fig. 1. Scanning electron microscopy (SEM) image of the surface and cross-section of (100) GaAs substrate anodized for 150 s in HF-KI electrolytes with low concentration of HF (a) and (c) and high concentration of HF (b) and (d). The white scale bar corresponds to 1 μm.

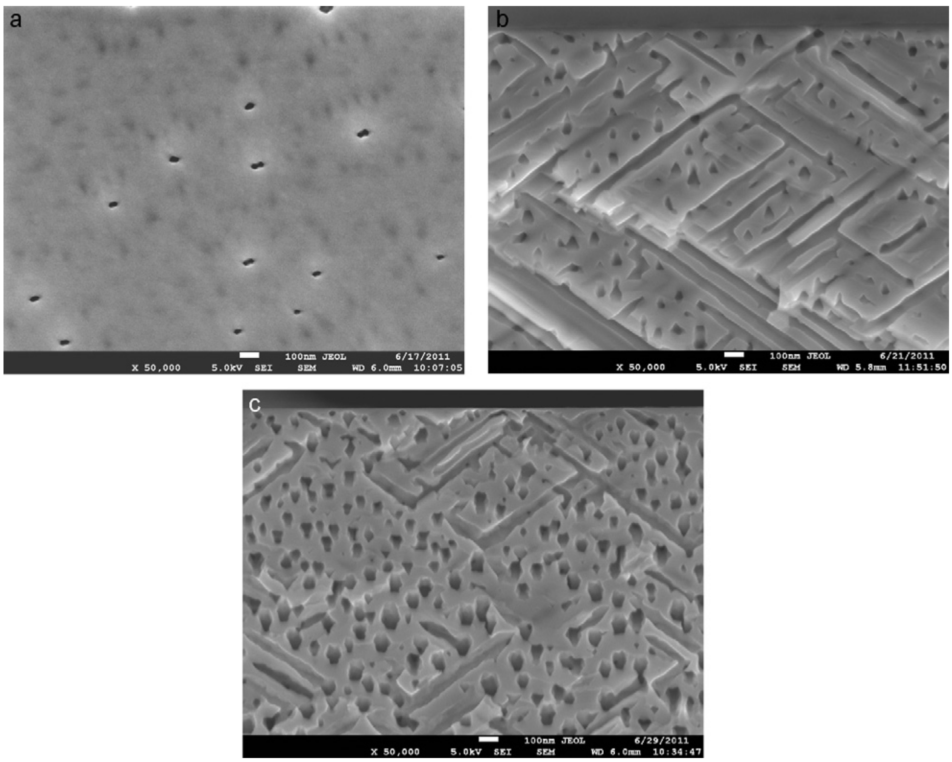

Fig. 2. High-magnification scanning electron microscopy (SEM) images of (100) GaAs substrate anodized for 150 s in HF-KI electrolytes with low concentration of HF: a: plan view; b: cross-section of the substrate cleaved along < 01 1 > direction; c: cross-section of the substrate cleaved along < 01–1 > direction. The total porous layer depth is 10 μm. The white scale bar corresponds to 100 nm.