POROUS ALUMINA MONOLITHICALLY INTEGRATED ON SEMICONDUCTING SUBSTRATES FOR OPTOELECTRONICS APPLICATIONS.

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Fabrication of semiconductor quantum dots (QD) arrays with size control and spacing is a noteworthy goal to achieve improvements in electronic and optoelectronic devices. Up to now, self – assembling process is the most successful approach to obtain QD.[1,2] This approach yields defect free QD of high optical quality and has been used to demonstrate QD lasers and other optoelectronic devices[3,4]. However, the characteristics of the QD based devices are far from those theoretically predicted, mainly due to the lack of size and density control of self-assembled QD. To solvent this limitation new approaches have being recently carried out to obtain highly ordered InAs QDs arrays using pre-patterned substrates[5,6]. One common approach is to transfer the pattern from a mask attached. In this way, self-ordered alumina nanochannels fabricated by electrochemical anodization[7] of an Al film have been used for fabrication of ordered 2D arrays of nanostructures.[8-12]

Our particular approach consists of anodizing a crystalline epitaxial aluminium layer, grown on GaAs (001) or InP (001) substrates by molecular beam epitaxy (MBE) in order to obtain porous alumina mask monolithically integrated on top of the substrate. Once the self-ordered alumina nanochannels are fabricated, a nanohole array can be developed on the substrate surface by continuing the anodization process once the interphase Al/substrate have been reached. The nanoholes can be used as preferential nucleation centres for QD formation, thus obtaining and ordered QD array.[13,14] The advantage of using an Al layer epitaxially grown on the semiconductor surface is that it preserves the surface between holes from contamination and defects produced during the otherwise necessary process to fix any mask over the semiconductor surface and ulterior etching. In this way, the preferential nucleation points for QD formation are exclusively the fabricated nanoholes.

For this work, Al layers were grown by MBE on Si-doped GaAs (001) and S-doped InP (001) substrates at room temperature. The morphology of the aluminium film and the patterned semiconductor surface is studied by atomic force microscopy (AFM). Structural characteristics of the layers are studied by *in situ* reflection high energy diffraction (RHEED) and x ray diffraction, Fig. 1.

The anodization of the aluminium is carried out in an electrochemical cell in the presence of oxalic acid at 40 V. The diameter of the pores is about 40 nm. Fig. 2 shows the substrate surface after anodization and alumina removal. The nucleation of the QD grown by MBE is preferential in the nanoholes, as shown in Fig. 3. In order to demonstrate the excellent optical quality of the grown material similar samples with 50nm GaAs capping layers were grown for photoluminescence (PL) measurements.

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Figures

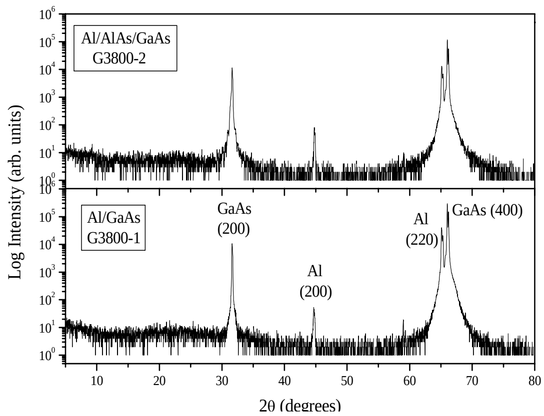

Fig 1: X-ray diffractograms of Al layer grown on AlAs/GaAs (top) and on GaAs (bottom) on silicon doped GaAs(001) substrates. The diffractograms show the coexistence of Al (110) and (100) crystallographic orientations.

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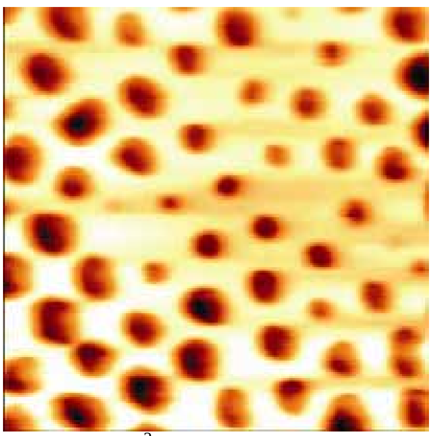

Fig 2: 1x1 μm^2 AFM image of patterned GaAs surface after alumina removal

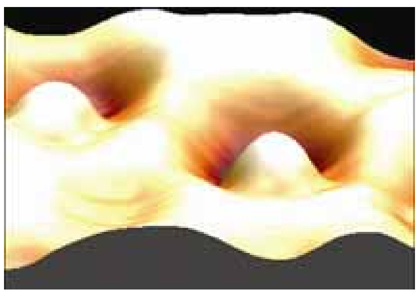

Fig. 3: 3D AFM image of InAs QD nucleated in the GaAs nanoholes.