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GaSb DOTS GROWN ON GaAs SURFACE BY METALORGANIC CHEMICAL VAPOUR DEPOSITION*

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We report metaloorganic chemical vapour deposition growth of an anisotropic GaSb islands on GaAs (001) surface with a typical dimensions around 200 nm. Results of investigations employing scanning electron microscope, scanning tunnelling microscope and photocapacitance are presented.

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Epitaxial growth of lattice mismatched heterostructures has been extensively investigated for many different systems. Strained epitaxial layers are unstable and after depositing few monolayers undergo transition from 2D to 3D growth mode. Such process helps to relieve strain arising from difference in lattice constants between the layer and the substrate and leads to formation of three-dimensional islands. Resulting structures are considered as technologically promising due to a lower density of defects comparing to their lithographically prepared counterparts. Moreover, understanding of initial steps of heteroepitaxial growth has crucial meaning for obtaining high quality epilayers.

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In the following paper we present results concerning GaSb on GaAs system. Lattice constants of GaAs and GaSb are respectively 5.65 Å and 6.09 Å. These give relative lattice mismatch of 7.8%, which is much higher than in the case of Ge on Si or GaInAs on GaAs, which are more often investigated systems. So far results for thin GaSb layers grown on GaAs were obtained for MBE grown samples [1, 2].

The investigated layers were grown in atmospheric pressure metaloorganic chemical vapour deposition (MOCVD) reactor with horizontal, RF-heated graphite susceptor. The growth of all discussed samples was performed at temperature of 575°C with trimethylgallium and trimethylantimony as Ga and Sb sources. The noncommercial metaloorganic compounds were synthetized by methods designed at Warsaw Technical University. The substrates were (001) oriented GaAs wafers. To improve surface quality, the GaAs buffer with thickness of 200 nm was grown prior to the GaSb deposition. The nominal thickness of the GaSb layers was in the range from 60 to 120 Å (growth rate was calibrated for 1 μm thick layer), which corresponds to 20–40 monolayers. For comparison we grew the reference sample consisting only of a GaAs buffer. We also investigated how the growth of the islands is influenced by initially strained buffers including 5 periods consisting of 60 Å GaSb and 100 Å GaAs layers. Such a structure should cause formation of the islands in the buried layers and thus enhance nucleation on the surface. Similar process was observed during growth of self-organised quantum disks in the multilayer InGaAs–GaAlAs system [3].

Images received from the scanning electron microscope (SEM) revealed presence of islands with an average density of 4×10^8 cm^{-2} (Fig. 1). The islands are ellipsoidal with a long axis parallel to the (110) direction. Typical lateral size (long axis) of the islands in the case of 60 Å thick layer grown on unstrained GaAs buffer is found to be of order of 2000 Å. The aspect ratio is around 3. The

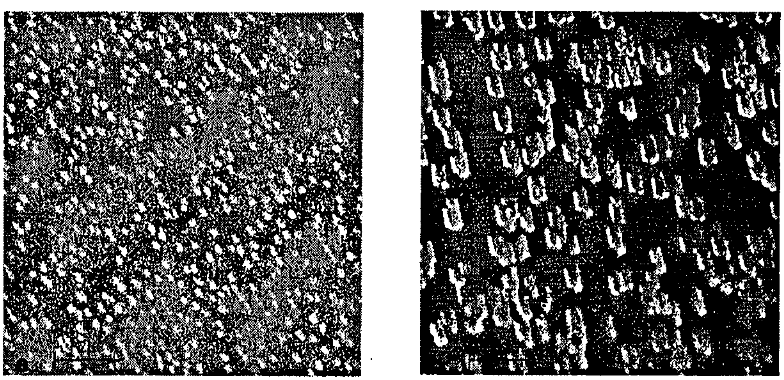

Fig. 1. SEM micrographs of GaSb island formed (a) on the initially unstrained GaAs buffer after depositing nominally 20 monolayers GaSb and (b) on the strained buffer after depositing of 40 monolayers GaSb. Note that total area covered with the islands is not proportional to the amount of deposited material but depends on the strain in the buffer.

scanning tunnelling microscope (STM) measurements allowed to determine the characteristic height of the islands, which exceeds 1000 Å. The height comparable with the lateral dimensions is an argument for strongly three-dimensional growth mode. Figure 1b shows islands formed on the strained buffer after deposition of nominally 120 Å GaSb layer. It is visible that the total area covered with islands increases much faster than the amount of deposited material.

It is theoretically predicted [4] that the GaSb/GaAs system is a type II heterostructure with GaSb conduction band about 0.5 eV above GaAs conduction band. It reduces the chance of observing photoluminescence for such a system. However, the existence of GaSb islands on GaAs buffer layer can be observed by means of electrical methods. Using the photovoltaic spectroscopy (PVS) option of the Bio-rad Electrochemical Profiler we measured a photovoltaic response of the material on illumination. We observed a broad band in PVS spectrum in the region of 1.0–1.4 μm. There was no structure of PVS spectrum which could be attributed to carrier confinement. This signal disappeared after removing nominally 5 nm of the material. Moreover, no such a band was found on PVS spectra measured on a reference sample.

We report results of technological studies of GaSb islands grown for the first time by atmospheric pressure MOCVD. The existence of GaSb islands has been directly observed by SEM and STM.

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