

Structural Defects in Growth of Multiple Period Self-Aligned InAs Quantum Dots on GaAs

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1. Introduction

During the heteroepitaxy of large lattice mismatch system such as InAs/GaAs($\approx 7.2\%$)[1], three dimensional island formation occurs, following a few monolayers(MLs) of pseudomorphic growth in a two dimensional layer-by-layer growth mode. Such findings had given impetus to the possible use of such islands as 3D confined structures referred to as quantum dots. It was reported that the deposition of 2 ~3 MLs of highly strained InAs on GaAs resulted in five periods of quantum dots[2]. Currently we have demonstrated that growth of InAs 20 periods of quantum dots on GaAs by repeating deposition of InAs and GaAs barrier layers. The InAs quantum dots were grown in self-aligned fashion, dot over dot, along the growth direction. However, some anomalies in the growth were also found. In this presentation, we will present the details of these structural defects in the growth InAs quantum dots on GaAs through the microstructural observations with transmission electron microscopy.

2. Experimental

Specimens were grown by a molecular beam epitaxy system equipped with 10 keV RHEED system, 0.3 μm thick GaAs buffer layer, 20 periods of 3 MLs of InAs and 11~20 nm thick GaAs barrier layer, and 30 nm GaAs capping layer were successively grown on a (001) oriented semi-insulating GaAs substrate. Growth interruption of about 1 min was introduced prior to the deposition of GaAs barrier layer. The growth temperature was 560°C for buffer GaAs layer and lowered to 500°C for the InAs and GaAs barrier layer as derived from the optical pyrometer. The growth rate was kept at 0.5 ML/sec and 0.09ML/sec for GaAs and InAs, respectively. The specimens for TEM observations were prepared by mechanical polishing, followed by Ar

ion milling with a acceleration voltage of 4 keV. Microstructural observations were carried out by H9000-NAR working at 300kV with a point resolution of 0.18 nm.

3. Experimental Results

Fig. 1 shows the cross-sectional TEM image of the 20 periods of InAs quantum dot structure. This image was taken in a high resolution TEM mode with [110] zone axis. The InAs islands are visible because In atoms have a greater scattering amplitude than Ga atoms. Although there exists uncertainty whether dots have formed or not in the area indicated by arrow, InAs quantum dots were grown in self-aligned fashion, dot over dot along the growth direction up to 20 epilayers. This behavior indicates that the upper quantum dot is preferably assembled on the place where the strain induced by the lower quantum dot is strongly localized. The spacing between the quantum dots was approximately 60 nm. Fig. 2 shows the high resolution TEM image of InAs quantum dots taken by [110] zone axis. The morphology of InAs dots is spherical cap and dots are coherent with GaAs barrier layer. Their height is 50Å and the size is about 400Å in diameter. The height of GaAs is 125Å.

However, there exists two anomalies in the growth of these quantum dot structure. One is the stoppage of quantum dot formation as the growth continues. The other one is the formation of volcano-like defects in the superlattice structure which are grown vertically along the growth direction. We are going to demonstrate these defects in the poster presentation.

4. References

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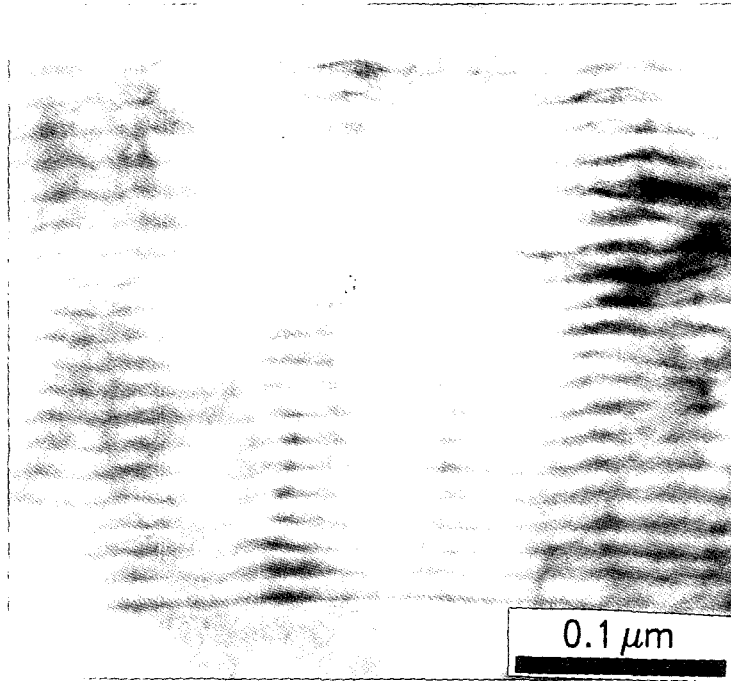


Fig. 1. Cross-sectional TEM micrograph of 20 periods of InAs quantum dots formed on a (001) GaAs substrate.

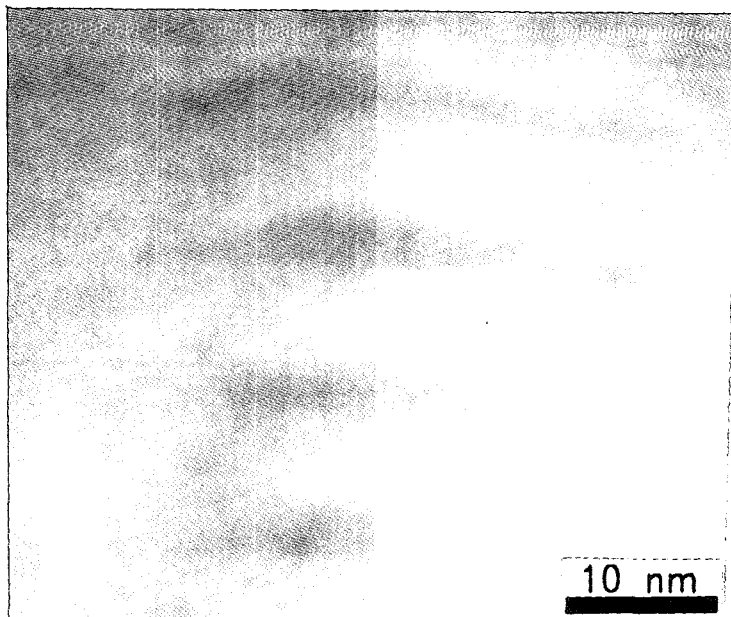


Fig. 2. High resolution TEM image of InAs quantum dots showing the morphology of a spherical cap.