doi:10.1017/S1431927610059702
Microsc. Microanal. 16 (Suppl 2), 2010

Strain Relaxation in Planar InAs Epitaxial Layers Studied by High-Resolution Transmission Electron Microscopy

K. Mahalingam, K. G. Eyink, M. Twyman, J. Shoaf, and L. Grazulis

Air Force Research Laboratory, Materials and Manufacturing Directorate, Wright-Patterson AFB, OH 45433-7707

The growth of epitaxial InAs thin films on (100)-GaAs surface is of significant interest for a variety of optoelectronic device applications. In particular, the formation InAs self-assembled quantum dots (SAQDs) during growth under *Arsenic-stabilized* conditions is an active field of research. The main driving force for SAQD formation is the reduction strain energy (due to a lattice mismatch of about 7%), which leads to a transition from planar to 3D-island growth mode when the surface coverage exceeds ≈1.65 monolayers (ML) (5Å). Comparatively less studied is the strikingly different growth mode exhibited when InAs is grown under *In-stabilized* conditions wherein, the InAs layer is observed to maintain a planar morphology from growth onset to well beyond the 1.65 ML limit (i.e. thicknesses around 60 Å) [1,2]. A particularly interesting feature in this growth mode is that strain relaxation occurs predominantly via formation of Lomer dislocations, with the extent of relaxation depending on growth conditions employed. The inherently low threading dislocation density combined with the possibility to control the degree of strain relaxation makes planar InAs thin films interesting materials for a variety applications, such as "tunable substrates" with lattice constants ranging from 5.65 Å(GaAs) - 6.06 Å(InAs).

In this work, we have performed a systematic study of the influence of growth conditions on the structure of planar InAs thin films. Specifically, we conducted several growth experiments wherein the substrate temperature was varied from 623K – 693K, under As flux conditions such that the In-rich (4x2) reconstruction was maintained. The samples so grown were investigated by plan-view and aberration-corrected cross-sectional high-resolution transmission electron microscopy (TEM). The plan-view TEM examination of all films examined revealed a well developed periodic array of Lomer dislocations (Fig. 1). Depending on growth temperature, the average dislocation spacing determined from these images was in the range 65Å – 88Å. In addition, the local strain relaxation in the InAs layer above and in-between dislocations in was determined from cross-sectional HRTEM lattice images (Fig. 2). A systematic dependence between the dislocation spacing, degree of strain relaxation and film thickness was also observed. Further details on the correlations between observed results and growth conditions employed will be presented.

1. A. Trampert et al. Appl. Phys. Lett. **66**, 2265 (1995).
2. W. J. Schaffer et al. J. Vac. Sci. Tech **B1**, 688 (1983).

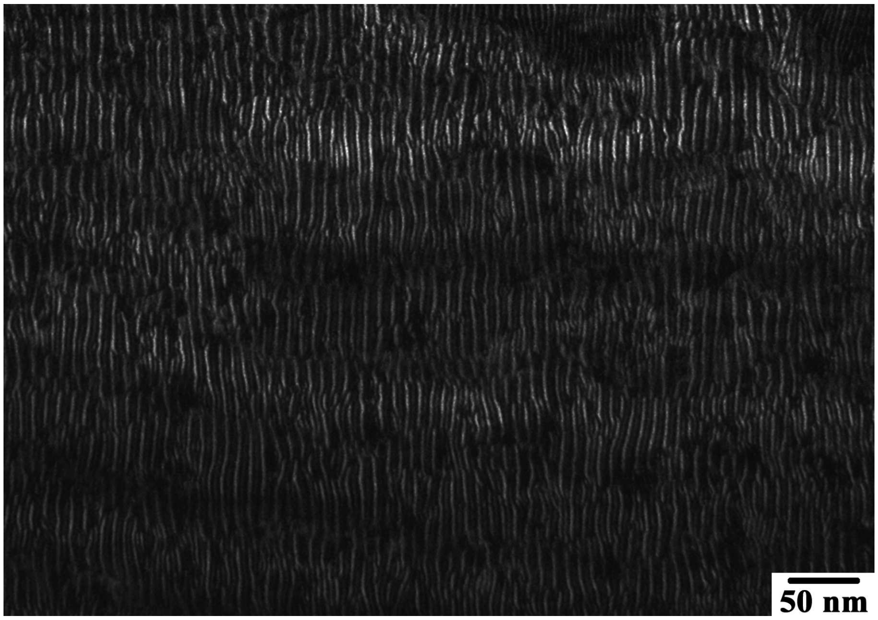

Fig. 1 Plan-view TEM image showing an array of Lomer dislocations in an InAs film grown on a GaAs substrate.

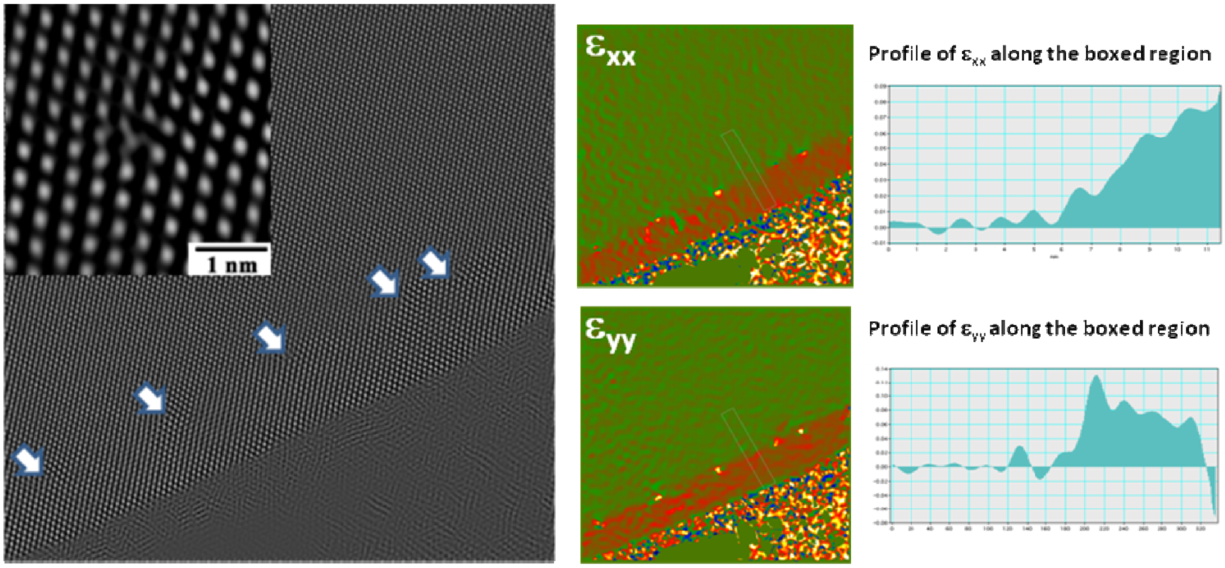

Fig. 2 (Left) [011] Cross-Sectional HRTEM image showing an array of Lomer dislocations (marked by arrows). Inset is magnified image of the dislocation core. (Middle) Color maps of the strain distribution, ε_{xx} (top) and ε_{yy} (bottom) determined from the HRTEM on the left image. The yellow centers corresponding to the arrows in HRTEM image are positions of the Lomer dislocations. (Right) Profiles of the strain distribution, ε_{xx} (top) and ε_{yy} (bottom), in the boxed region in the middle.