# Materials Science and Engineering Doctoral Defense

## Investigation of Strain Relaxation Mechanisms and Interfacial Defects in Lattice-mismatched GaAs(001)-based Heterostructures

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## Abstract


The evolution of defects at different stages of strain relaxation in low-mismatched GaAs/GaAs1-xSbx/GaAs(001) (x ~ 0.08) heterostructures, and the underlying relaxation mechanisms, have been comprehensively studied primarily using transmission electron microscopy (TEM). Aberration-corrected scanning transmission electron microscopy (STEM) has been used for atomic-scale study of interfacial defects in low-mismatched GaAs(001)-based and high-mismatched GaSb/GaAs(001) heterostructures. Three distinct stages of strain relaxation were identified in GaAs/GaAs1-xSbx/GaAs(001) (x ~ 0.08) heterostructures with GaAsSb film thicknesses in the range of 50 to 4000 nm capped with 50-nm-thick GaAs layers. Diffraction contrast analysis with conventional TEM revealed that although 60° dislocations were primarily formed during the initial sluggish Stage-I relaxation, 90° dislocations were also created. Many curved dislocations, the majority of which extended into the substrate, were formed during Stage-II and Stage-III relaxation. The capping layers of heterostructures with larger film thickness (500 nm onwards) exhibited only Stage-I relaxation. A decrease in dislocation density was observed at the cap/film interface of the heterostructure with 4000-nm-thick film compared to that with 2000-nm-thick film, which correlated with smoothening of surface cross-hatch morphology. Detailed consideration of plausible dislocation sources for the capping layer led to the conclusion that dislocation half-loops nucleated at surface troughs were the main source of threading dislocations in these heterostructures.Aberration-corrected STEM imaging revealed that interfacial 60° dislocations in GaAs/GaAsSb/GaAs(001) and GaAs/GaAsP/GaAs(001) heterostructures were dissociated to form intrinsic stacking faults bounded by 90° and 30° Shockley partial dislocations. The cores of the 30° partials contained single atomic columns indicating that these dislocations primarily belonged to glide set. Apart from isolated dissociated 60° dislocations, Lomer-Cottrell locks, Lomer dislocations and a novel type of dissociated 90° dislocation were observed in GaAs/GaAsSb/GaAs heterostructures.The core structure of interfacial defects in GaSb/GaAs(001) heterostructure was also investigated using aberration-corrected STEM. 90° Lomer dislocations were primarily formed; however, glide-set perfect 60° and dissociated 60° dislocations were also observed. The 5-7 atomic-ring shuffle-set dislocation, the left-displaced 6-8 atomic-ring glide-set and the right-displaced 6-8 atomic-ring glide-set dislocations were three types of Lomer dislocations that were identified, among which the shuffle-set type was most common.

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Zoom Link: https://asu.zoom.us/j/85490643502