Microstructure, chemical composition, and surface morphology of InAsSbBi grown on GaSb by molecular beam epitaxy

Rajeev R. Kosireddy,[1,+] Stephen T. Schaefer,[2] Shane R. Johnson[2]

[1] *Center for Photonics Innovation & School for Engineering of Matter, Transport, and Energy, Arizona State University, Tempe, AZ, USA*

[2] *Center for Photonics Innovation & School of Electrical, Computer, and Energy Engineering, Arizona State University, Tempe, AZ, USA*

The microstructure, chemical composition, and surface morphology of molecular beam epitaxy grown InAsSbBi is investigated using transmission electron microscopy (TEM), X-ray diffraction, and atomic force microscopy (AFM). The InAsSbBi layers are 210 nm thick and grown at temperatures between 400 and 430 °C on (100) GaSb substrates. The results indicate that the material is nearly lattice matched, coherently strained, and contains dilute Bi mole fractions. The bright field TEM image in Fig. 1 shows no visible defects in the material over large lateral distances. Lateral modulation of the Bi mole fraction is observed in the bright field image and in the chemical sensitive 200 dark field image shown in Fig. 2, where a line scan of the image intensity along the black rectangle is inset. Analysis of the ratio of the dark field image intensities indicates that the Bi mole fraction variation has about a 30 nm period and ranges from 0.42% to 0.58% with a 0.50% average value. A rough hazy surface with large Bi-rich droplets on the order of 1 µm diameter is observed when the InAsSbBi layer is grown with near stoichiometric As flux (see Fig. 3). Nevertheless, when the As flux is a few percent greater than stoichiometric, a smooth specular surface without large droplets is observed (see Fig. 4). The growth temperature and the As, Sb, and Bi over In flux ratios are listed in each figure. The results at higher growth temperature also show a similar dependence on the As flux. The surface interaction between As and Bi strongly affects the surface morphology and the incorporation of Bi into the InAsSbBi layer.

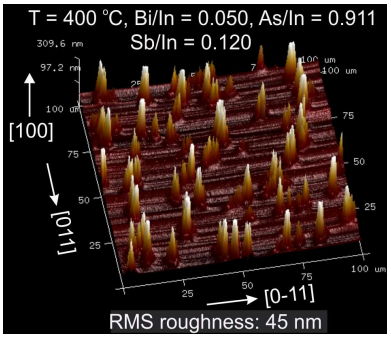

Figure 3. 100 µm by 100 µm AFM image of a hazy Bi-rich droplet covered surface.

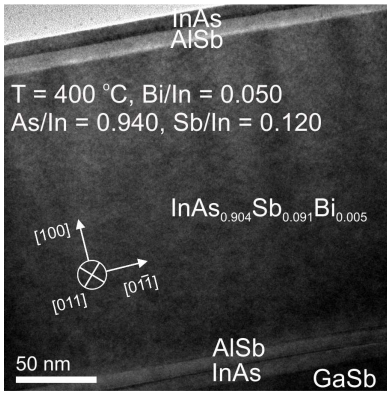

Figure 1. Bright field TEM image showing no visible defects over large lateral distances.

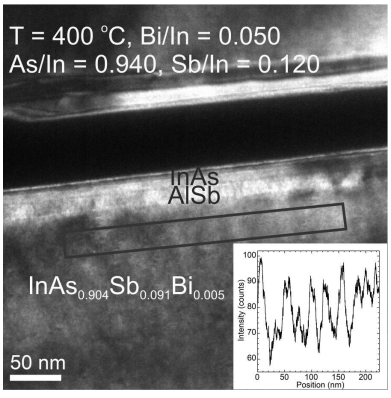

Figure 2. 200-dark field TEM cross-section with a line scan of image intensity inset.

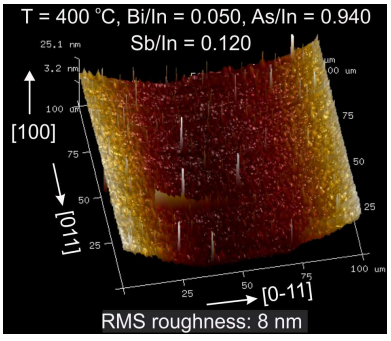

Figure 4. 100 µm by 100 µm AFM image of a specular surface without Bi-rich droplets.

[+] Author for correspondence: rkosired@asu.edu