InAsSbBi/GaAsSbBi type-II heterostructures for mid- and long-wavelength infrared applications

Shane R. Johnson,[1] Stephen T. Schaefer,[1] Rajeev R. Kosireddy,[1] Arvind J. Shalindar,[1] Preston T. Webster[2]

[1] Center for Photonics Innovation & Fulton School of Engineering, Arizona State University, Tempe, AZ 85287, USA

[2] Air Force Research Laboratory, Space Vehicles Directorate, 3550 Aberdeen Ave. SE, Kirtland AFB, NM 87109, USA

Alloying bismuth with InAsSb provides an active material near the GaSb lattice constant that covers the technologically important 3 – 5 μm and 8 – 12 μm atmospheric transmission windows. A significant advantage of the InAsSbBi quaternary is that strain and bandgap can be independently selected (Fig. 1). Furthermore, independent tuning of the band offsets can be achieved when adding the larger bandgap GaAsSbBi quaternary to the mix, either as quinary random alloys or type-II quantum well/superlattice heterostructures.

The molecular beam epitaxy growth and structural and optical properties of InAsSbBi/GaAsSbBi heterostructures on GaSb are examined using reflection high-energy electron diffraction, Rutherford backscattering spectrometry, X-ray diffraction, spectroscopic ellipsometry, and photoluminescence spectroscopy. Near stoichiometric group-V fluxes and lower growth temperatures are utilized to facilitate the incorporation of the Bi atoms. The Rutherford backscattering spectrum from InAsSbBi has a unique energy range characteristic of Bi, allowing independent determination of Bi mole fraction (Fig. 1). The As and Sb mole fractions are then uniquely determined from the layer strain provided by X-ray diffraction. The InAsSbBi bandgap and band offsets determined from photoluminescence and spectroscopic ellipsometry are parametrized in terms of mole fraction. The results indicate that the InAsSbBi material system forms a type-I band alignment with InAsSb and a type-II band alignment with GaSb and GaAsSbBi.

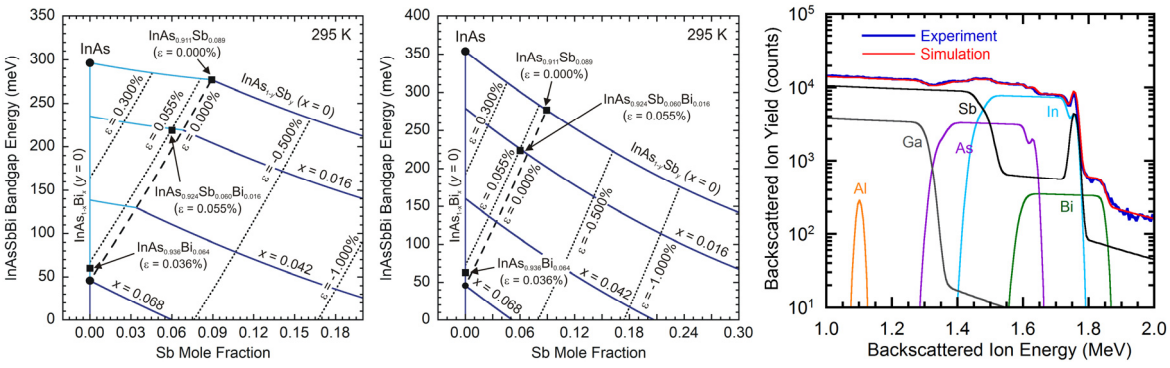

Figure 1. Room temperature bandgap of $InAs_{1-y-x}Sb_yBi_x$ [1], pseudomorphically strained on GaSb (left), unstrained bulk material (center). Rutherford backscattering measurements of $InAs_{0.924}Sb_{0.060}Bi_{0.016}$ (right).

[1] Preston T. Webster, Arvind J. Shalindar, Stephen T. Schaefer, Shane R. Johnson, Bandgap and composition of bulk InAsSbBi grown by molecular beam epitaxy, Appl. Phys. Lett. **111**, 082104 (2017).

[+] Author for correspondence: shane.johnson@asu.edu