Minority Carrier Lifetime and Photoluminescence Properties of Mid-Wave InAsSbBi

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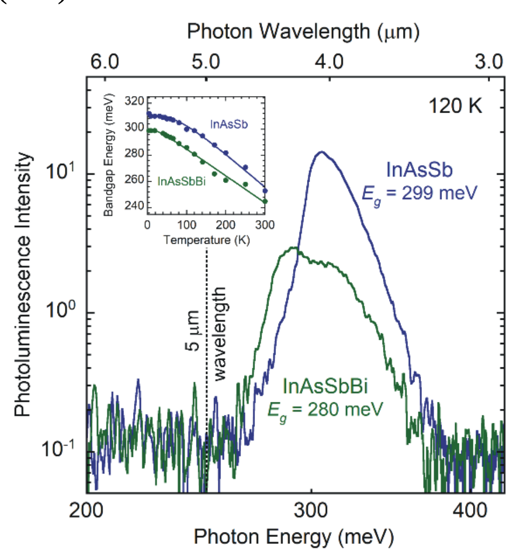
As lower cost infrared imaging goals drive research in alternatives to state-of-the-art HgCdTe, the unparalleled bandgap engineering flexibility afforded by the heaviest group-V element Bi offers a unique III-V analog to HgCdTe in InAsSbBi. By varying the mole fraction of constituent lattice-matched ternaries $InAs_{0.91}Sb_{0.09}$ (4 µm wavelength at 120 K) and $InAs_{0.93}Bi_{0.07}$ (12 µm wavelength), quaternary InAsSbBi spans the technologically relevant mid- to long-wave infrared spectrum and can be grown lattice-matched on large area GaSb substrates. Moreover, InAsSbBi's compositional likeness to conventional bulk InAsSb and the InAs/InAsSb superlattice put it in a unique position to take advantage of recent technological innovation discovered and implemented in these related infrared systems.

Molecular beam epitaxy grown InAsSbBi alloys are examined using temperature-dependent steady-state and time-resolved photoluminescence spectroscopy, X-ray diffraction, reflection high-energy electron diffraction (RHEED), and Nomarski imaging. RHEED patterns show that the InAsSbBi layer grows with a droplet-free (2×3) surface reconstruction at 380 °C. The surface is observed to remain specular and droplet free during growth, and Nomarski imaging further verifies that a smooth surface morphology is obtained. The InAsSbBi layers are 1 µm thick sandwiched between lattice-matched InAsSb layers providing carrier confinement. Comparison of the tetragonal distortion measured by X-ray diffraction and the bandgap energy measured by steady-state photoluminescence provides an evaluation of the Sb and Bi content of each sample. The target InAsSbBi mole fractions yielding 5 µm wavelength emission are 6.0% Sb and 2.2% Bi, and detailed examination of the photoluminescence properties and molecular beam epitaxy growth conditions show the growth progression towards this goal. Bandgap characteristics and recombination dynamics evaluated from the photoluminescence experiments are compared to equivalent 5 µm wavelength InAs/InAsSb superlattices and 4 µm wavelength lattice-matched InAsSb bulk samples.



Photoluminescence from $InAs_{0.898}Sb_{0.102}$ and $InAs_{0.931}Sb_{0.055}Bi_{0.014}$ on GaSb shows a 19 meV bandgap shift to 4.43 µm wavelength at 120 K. Broadening in the InAsSbBi spectrum may be attributable to luminsecent InAsSb in the structure. Inset shows temperature dependence of the bandgap energy.

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