Optimizing the design of type-II InAs/InAsSb superlattices for the incorporation of unintentional Sb in the tensile electron well

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Several strain-balanced 5.3 µm midwave and 12.0 µm longwave InAs/InAsSb superlattices are grown on (100) GaSb substrates by molecular beam epitaxy and examined using X-ray diffraction and temperature-dependent photoluminescence. A significant amount of surface Sb incorporates into the tensile InAs layer that subsequently affects the design and performance. For a given wavelength design the presence of unintentional Sb in the InAs layer i) increases the tensile electron well thickness, thereby increasing electron confinement and decreasing electron wavefunction intensity, ii) decreases hole well depth, thereby decreasing hole well width and hole confinement, and as a result iii) decreases the absorption coefficient by 8% for midwave and 11% for longwave. This is presented in Figure 1 in terms of total wavefunction overlap and that within the tensile and compressive layers for structures with and without unintentional Sb as a function of the compressive layer Sb mole fraction. The solid curves show the case with unintentional Sb and the dashed curves show the case without unintentional Sb, with the compressive layer in red, the tensile layer in black, and the total (sum of red and black) in blue. The values for the grown superlattices are shown as open circles. The measurements and calculations are for an operating temperature of 77 K. The grown superlattice tetragonal distortion ranges from -0.019% to 0.020% with a -0.001% average for midwave and from 0.021% to 0.039% with a 0.027% average for longwave. A combination of X-ray diffraction and photoluminescence is utilized to determine that the unintentional Sb mole fraction in tensile layer is 1.9% for midwave and 1.2% for longwave.

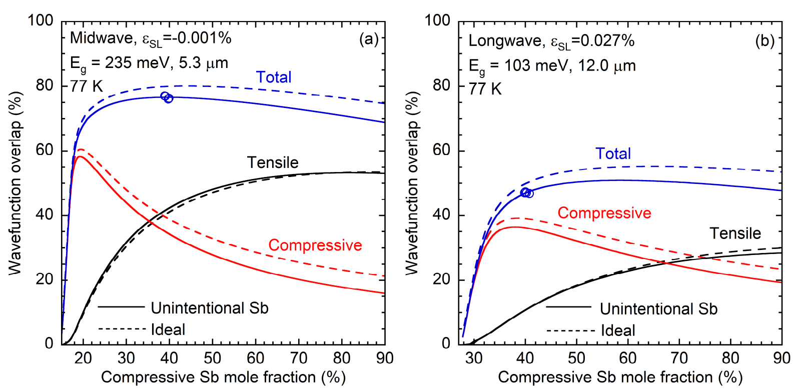

Figure 1. Electron-hole wavefunction overlap in 5.3 µm midwave (a) and 12.0 µm longwave (b) InAs/InAsSb superlattices.

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