Minority Carrier Lifetime and Recombination Dynamics in Strain-Balanced GaInAs/InAsSb superlattices

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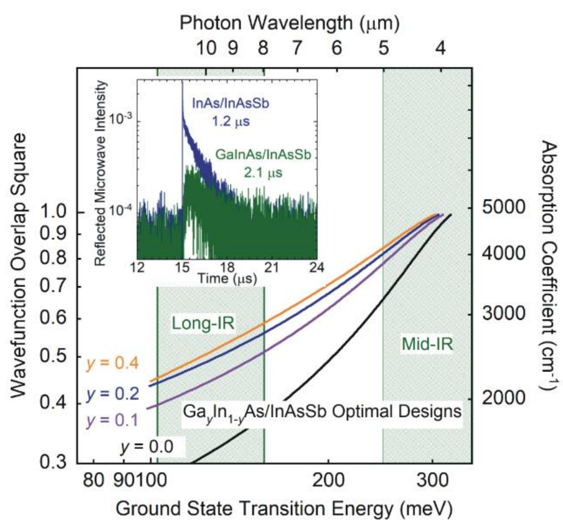
Strain-balanced InAs/InAsSb superlattices are rapidly emerging as a contending mid-infrared sensing technology as decreasing dark currents lead to ever more sensitive detectors. Dark current can be minimized by increasing the absorption coefficient and utilizing a thinner absorber region, thereby reducing the volume over which dark current is generated. While the InAs/InAsSb superlattice design may be optimized for maximum absorption [1], there remains great room for improvement by establishing a more favorable strain-balance condition. Specifically, replacing the lightly-tensile InAs layers with more-tensile GaInAs leads to a more symmetric wavefunction overlap profile and correspondingly stronger absorption for the same energy cutoff [2]. The figure plots the wavefunction overlap square and absorption coefficient of GaInAs/InAsSb superlattices designed for maximum absorption as a function of ground state transition energy, which shows that absorption coefficient improves substantially with Ga content up to 20%.

In this work, two strain-balanced GaInAs/InAsSb superlattices (0% and 20% Ga) designed for maximum absorption at 5 µm wavelength are examined using temperature- and excitation-dependent photoluminescence spectroscopy and time-resolved microwave reflectance. The superlattices are 1 µm thick and doped 4×10^{15} cm^{-3} *n*-type in order to examine the optimal doping density × lifetime product in a potential diffusion-limited detector [3]. The 77 K time-resolved microwave reflectance decay for each sample is plotted in the figure inset, with the minority carrier lifetimes of 1.2 µs and 2.1 µs labeled in the plot. The photoluminescence is evaluated using a recombination rate model to extract the Shockley-Read-Hall, radiative, and Auger rate constants as a function of temperature, to compare to the temperature-dependent minority carrier lifetimes determined by the time-resolved photoconductivity decay.



Wavefunction overlap square and absorption coefficient of GaInAs/InAsSb superlattice designs. Inset shows photoconductivity decay of 5 um wavelength designs with 0% and 20% Ga in GaInAs.

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