Optical characterization and pump-probe measurements of InAs/GaSb and InAs/InAsSb type-II superlattices

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Modern optical gas detection systems utilize the technique of tunable diode laser absorption spectroscopy (TDLAS) for different applications in science, manufacture, or medicine. [1] Through tuning the emission wavelength, the presence and concentration of trace gases are possible to detect in real-time with their limit in single ppb range. Optical gas detection systems employing mid-infrared spectral range often comprise of active structures grown within so called 6.1 Å family of semiconductors, i.e. InAs, GaSb, AlSb alloys. Superlattice structures within this material system with type-II alignment have the potential to exceed the working parameters of widely used optoelectronic devices, such as HgCdTe infrared photodetector. [2]

Optically active type-II superlattices were obtained through molecular beam epitaxy and then characterized utilizing Fourier-transform infrared spectrometer (FTIR) and pump-probe system. The measurements were performed on two sets of structures – type-II InAs/GaSb superlattices and type-II Ga-free InAs/InAsSb superlattices. The parameter varying the samples within the first set was the approach to interface engineering – the samples were either "Sb-soaked" or an InSb monolayer was inserted between each SL period [3] which was also considered in our previous works. [4] Samples within the second set, on the other hand, varied through SL periodicity of 5, 6 and 8 nm which allowed to shift the main transition from 5 to 9 μm at room temperature. [5]

Photoluminescence spectra were obtained for all samples in 10 to 300K temperature range and then complemented with photoreflectance measurements for characteristic temperatures to increase the sensitivity of the measurement for less optically active transitions. In addition, pump-probe measurements were performed to investigate the dynamics of carrier relaxation and recombination processes in proximity of transition energies observed in previous experiments.

Presented findings could provide valid insights in the fundamental properties such as carrier lifetimes within InAs/GaSb and InAs/InAsSb SLs to further optimize and improve the working parameters of possible future applications in the field of infrared optoelectronics.

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