Monte Carlo simulation of tunable mid-infrared emission from coupled Wannier-Stark ladders in semiconductor superlattices

We present a theoretical and experimental study on the mid-infrared electroluminescence associated with transitions between electric-field-induced conduction states, forming the Wannier–Stark ladder, in strongly coupled GaAs/AlAs superlattices. The interwell and intrawell radiative transitions in the whole range of electric fields from the moderate localization to the resonance-induced delocalization regimes have been experimentally investigated. Monte Carlo simulations show a very good agreement between experimental and theoretical electroluminescence spectra. Results show that the application of an electric field in the range from 100 to 250 kV/cm shifts the emission peak, related with interwell diagonal transitions between Stark-localized ground states of two adjacent wells, up to the limit corresponding to the merging of this electroluminescence peak with the intersubband emission between excited and ground state of the same well. The theoretical investigation indicates that interwell scattering via LO phonons is responsible for the population of the excited state of the ladder.