



Phonons in self-assembled Ge/Si structures

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Abstract

We present the results of an investigation dealing with fundamental vibrations in periodical Ge/Si structures with small-size Ge quantum dots (QDs) performed using macro- and micro-Raman spectroscopy under resonant and off-resonant conditions. Samples with different number of repetition of Ge and Si layers contain Ge QDs with an average dot base size of 15 nm and a QD height of 2 nm. Periodic oscillations observed in the low-frequency region of the Raman spectra are assigned to folded LA phonons in the Ge QD superlattices. The measured phonon frequencies are in a good agreement with those calculated using the Rytov model. These oscillations are superimposed with a broad continuous emission originating from the whole acoustic dispersion branch due to a breaking up of translational invariance. The Raman spectra of the structure with single Ge QD layer reveal a series of peaks corresponding to LA phonons localized in the Si layer. Using the measured phonon frequencies and corresponding wave vectors the dispersion of the LA phonons in the Si is obtained. The longitudinal-acoustic wave velocity determined from the dispersion is 8365 ms^{-1} and in excellent agreement with that derived from the Brillouin study. In the optical phonon range, the LO and TO phonons localized in Ge QDs are observed. The position of the LO Ge phonons shifts downwards with increasing excitation energy (from 2.5 to 2.7 eV) indicating the presence of a QD size distribution in Ge dot superlattices. Raman scattering from Ge QDs is size-selectively enhanced by the resonance of the exciting laser energy and the confined excitonic states.

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