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Phonons in Quantum-Dot Quantum Well

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Abstract: Phonon modes of AlAs/GaAs/AlAs and GaAs/AlAs/metal Pb quantum-dot quantum wells (QDQW's) with the whole scale up to 90 \AA are calculated by using valence force field model (VFFM) based on group theory. Their optical frequency spectra are divided into two nonoverlapping bands, the AlAs-like band and the GaAs-like band, originated from and having frequency interval inside the bulk AlAs optical band and bulk GaAs optical band, respectively. The GaAs-LO (Γ)-like modes of QDQW's that have maximum bulk GaAs-LO (Γ) parentages in all modes covering the whole frequency region and all symmetries have always A_1 symmetry. Its frequency is controllable by adjusting the structure parameters. In AlAs/GaAs/AlAs, it may be controlled to meet any designed frequency in GaAs-like band. The results on GaAs/AlAs/metal Pb QDQW's show the same effect of reducing in interface optical phonons by using the metal/semiconductor interface revealed ever by macroscopic model. The frequency spectra in both GaAs-like and AlAs-like optical phonon bands are independent of the thickness of Pb shell as long as the thickness of Pb shell is no less than 5 \AA. Defects at metal/AlAs interface have significant influence to AlAs-like optical modes but have only minor influence to GaAs-like optical modes. All these results are important for the studying of the e-ph interaction in QD structures.

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