An Alternative Approach to the Calculation of The Electron-Phonon Interaction in Semiconductor Nanostructures

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The polar optical vibrations are essential for the transport properties in semiconductor nanostructures because they are the source of a strong electron-phonon interaction. The commonly used macroscopic models (see for [1] and the bibliography therein) treat the optical phonon displacements as a spatially smooth functions. Our calculation in the realistic three-dimensional lattice-dynamical model [2] reveals that the actual picture of phonon electric fields deviates from a commonly used conceptions. The anion-cation displacements in the finite wave-vector vibration depend on the unit cell's choice and so are not well-defined quantities in a continuum approximation. Actually it is the reason of the boundary conditions' incompatibility [1] at the interface in the superstructure's phonon problem. We offer the alternative macrocsopic approach based on the non-local dielectric screening theory. This method provides a regular way to obtain the continuum limit from the microscopic lattice dynamical equations and it properly takes into account the local field corrections [2]. The electron-phonon potentials actually appears to be the eigenfunctions of the dielectric matrix. The interface matching problem does not arise at all. In the dispersionless continuum model for a nanostructure we derive the closed and tractable analytical expressions both for the phonon frequencies and the electron-phonon potentials. The connection of the long-wave irregular behavior of solutions with the geometry of a superstructure is essentially clarified. The problem of a short-range dispersion arises in the realistic models of nanostructures [1]. This problem also finds out the most natural way of solution in our approach and needs not any artificially-looking constructions like the so-called interface phonon fields [1]. We succeed to get a tractable analytical expressions for the phonon electric fields with the short-range dispersion included. The long-wave-phonon dispersion curves and the electron-phonon potentials are in the excellent agreement with those calculated for $GaAs_n/AlAs_m[001]$ superlattice in the elaborated lattice dynamical bond-charge model [2]. We believe that our results are to be useful for the solution of the carrier transport problem in the semiconductor superlattices.

[1] B.K.Ridley, O.Al - Dossary, N.C.Constantinou, and M.Babiker, Phys.Rev.B **50**, pp. 11701–11709 (1994).

[2] V.G.Tyuterev, J.Phys.: Cond.Matt. **11**, pp. 2153–2169 (1999).