NONLINEAR EFFECTS OF ENERGY BAND STRUCTURES ON OPTICAL TRANSITIONS IN QUANTUM DOTS

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The quantum theory of nonlinear effects for optical transitions of electrons in quasi-zero-dimensional (Q0D) quantum dots fabricated from n-type III-V compound semiconductor materials such as n-type GaAs has been studied due to the nonparabolicity of energy band structures. We use the effective mass approximation for carriers in the quantum dots. Most realistic quantum dot systems contain the box with a thickness c and the lateral width (a,b). Using the time independent perturbation theory, the first order correction of the eigenfunctions and eigenvalues for the system has been calculated. Since we are interested in nondegenerate semiconductors, the distribution function of carriers can thus be used a Maxwell-Boltzmann distribution. And the free-carrier absorption coefficient may be calculated for Q0D quantum dots from n-type GaAs where the polar optical phonon scattering is dominant. Results are shown that the free-carrier absorption coefficient in Q0D quantum dots increases quite rapidly with increasing temperature in the region of low temperatures. When temperatures are larger than 100 K, the free-carrier absorption coefficient increases slowly with temperature. This shows that the nonlinear property of energy band structures due to the nonparabolicity plays an important role in low temperatures. The discution about the dot size effect of the quantum confinement region in n-type GaAs quantum dots has also been given.