Intraband optical properties of self-assembled columnar quantum dots

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A new type of self-assembled quantum-dot structures with a large height to diameter ratio, so called columnar quantum dots or quantum rods (posts), have been recently experimentally realized [1]. Their most valuable advantage is the very precise controllability of the height and therefore the diameter/height aspect ratio. The eight band $\vec{k} \cdot \vec{p}$ model [2] was used in this work to understand the electronic and infrared intraband optical properties of InGaAs/GaAs cylindrical quantum rods. The eigenvalue problem of the Hamiltonian was solved using the wave function expansion method, where the basis of eigenfunctions of a particle in a cylinder with infinite walls was used [2]. The optical absorption spectrum from the ground state in the conduction band was calculated in the dipole approximation using first order perturbation theory. Gaussian broadening with a standard deviation equal to 10% of the transition energy was used to take into account the inhomogeneity of the ensemble. An example of intraband optical absorption calculation is given in Figure 1. The height of the cylindrical rods with an In composition of 45% [1] was varied from 20 nm to 40 nm whilst keeping the diameter at 10 nm. The rods were positioned in surrounding quantum well with an In composition of 16% [1]. The clear tunability of the absorption peaks for *z*-polarized (growth direction) incident radiation with rod height was noticed ranging from 2--6 THz (see Figure 1, right panel). Absorption spectra of *x*-polarised incident radiation are also given in Figure 1, left panel, with main peak in range 4.5—5.5 THz. An excellent prospect of integration of analysed structures with well established THz radiation sources based on GaAs quantum-cascade laser technology is predicted.

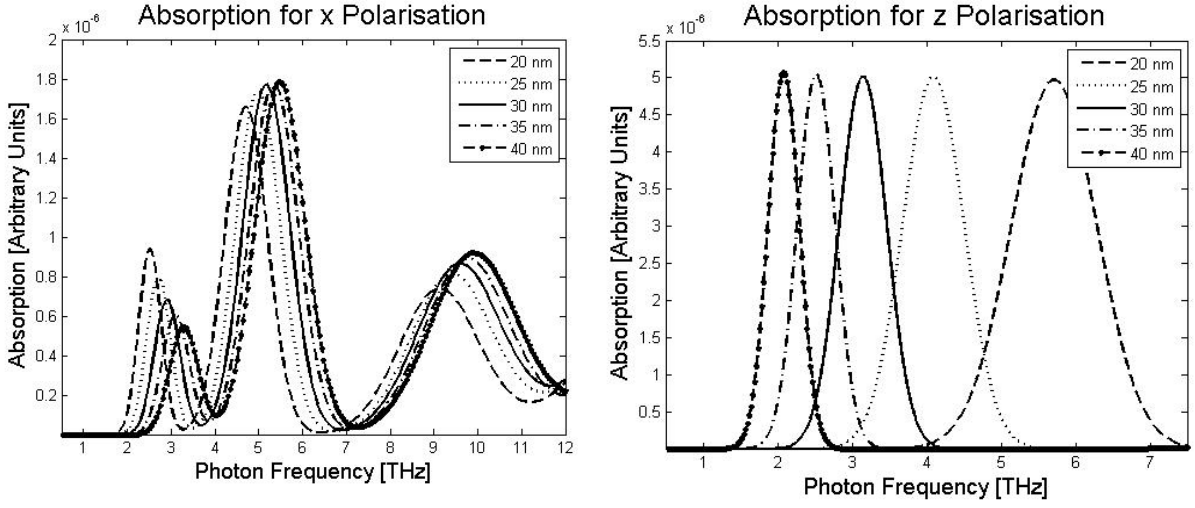

Figure 1. The intraband optical absorption from the ground state in the case of *x*-polarized (left panel) and *z*-polarized (right panel) incident radiation as a function of quantum rod height.

References

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