Comparison of the electronic structure of InAs/GaAs pyramidal quantum dots with different facet orientations

Jeongnim Kim,* Lin-Wang Wang, and Alex Zunger
National Renewable Energy Laboratory, Golden Colorado 80401
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Using a pseudopotential plane-wave approach, we have calculated the electronic structure of strained InAs pyramidal quantum dots embedded in a GaAs matrix, for a few height (h)-to-base(b) ratios, corresponding to different facet orientations \$101%, \$113%, and \$105%. We find that the dot shape ~not just size! has a significant effect on its electronic structure. In particular, while the binding energies of the ground electron and hole states increase with the pyramid *volumes* (b^2h), the splitting of the p-like conduction states increases with facet *orientation* (h/b), and the p-to-s splitting of the conduction states decreases as the *base size* (b) increases. We also find that there are up to six bound electron states ~12 counting the spin!, and that all degeneracies other than spin, are removed. This is in accord with the conclusion of electron-addition capacitance data, but in contrast with simple $\mathbf{k}\cdot\mathbf{p}$ calculations, which predict only a single electron level. @S0163-1829~98!50516-4#

Growth of semiconductor quantum dots via controled coarsening of lattice-mismatched films[1] produces coherently strained islands. These ''self-assembled'' dots, capped by another semiconductor, exhibit rich spectroscopic features, including explicit evidence of quantum-confinement,[2] size and shape effects on the spectrum,[3,4] emission from higher excited states,

boundary conditions in all three principal directions. We use
@100

$101% and $113% faceted dots, while it also has significant amplitude in the barrier for the $105% faceted dots. The shape

P_1 5 ^C_iɯP_x 1 P_yɯV_j&, P_2 5 ^C_iɯP_x 2 P_yɯV_j&, and P_z 5 ^C_iɯP_zɯV_j&, where x,y and z denote the @100#, @010#, and @001# directions, respectively. We find the following:

~a! For the $101% faceted dots, the transitions from the ground electron state C_s to the ground hole state (V_0) and to the excited hole states (V_1 and V_2) are allowed. Their transition dipole moments strongly depend on the polarization: the $C_s \rightarrow V_0$, $C_s \rightarrow V_1$, and $C_s \rightarrow V_2$ transitions are allowed for polarization P_1, P_z, and P_2, respectively.

~b! For the $113% faceted dots, the transition from C_s to V_0 is forbidden ~dark exciton!, while it is allowed for $101% and $105% faceted dots.

~c! There are no dipole-allowed transitions polarized along the z direction (P_z transitions! for the flatter $105% faceted dot. On the other hand, we find three transitions, $C_s \rightarrow V_1$, $C_{p\,2}$