Structural Transitions in Epitaxial and Endotaxial Self-Assembled Semiconductor Quantum Dots

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Transmission electron microscopy (TEM) in atomic resolution revealed structural and morphological transitions in epitaxial and endotaxial self-assembled II-VI, III-V, and group IV semiconductor quantum dots. These transitions result in compressively strained quantum dots being converted into lower energy structures. Because there is an essentially hydrostatic pressure of some 10 GPa on typical compressively strained quantum dots, structural reorganization is driven toward orientation relationships that minimize the elastic mismatch strain energy. We believe that it is the release of excess Gibbs free energy that drives the structural transitions, proceeding by either atomic ordering, spinodal decomposition, or phase transitions. An estimate of the excess Gibbs free energy in a typical compressively strained quantum dot at room temperature yields a value of the order of magnitude 1 eV per atom. The implications for the lifetime of prospective devices that involve epitaxial and endotaxial semiconductor quantum dots are discussed.