Self-Assembled Semiconductor Nanostructures: Multi-Scale Experimentation

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Recently, ordered arrangements of semiconductor nanostructures have shown significant promise for a wide range of electronic, optoelectronic, and magnetic applications. In most cases, stress plays a key role in the formation and stability of these nanostructures. For example, arrays of semiconductor nanostructures are easily produced in systems AB, where A and B have different atomic sizes. An example is a semiconductor quantum dot, which may be produced by the elastic relaxation of stress via nucleation of islands of A on a substrate B. Repetition of the process leads to the vertical alignment or "stacking" of the islands of A. A related semiconductor nanostructure is one produced by the stress-induced decomposition of an alloy film. For example, in an alloy film AB or a superlattice A/B/A/B, spontaneous lateral phase separation often leads to the formation of lateral superlattices consisting of alternating A- and B-rich layers. Another method for producing nanostructures is the controlled nanoscale crystallization of A from an amorphized layer AB. In this talk, I will discuss our multi-scale experimental studies which reveal new mechanisms for ordering of InAs/GaAs quantum dot superlattices [1], spontaneous lateral phase separation in InAlAs alloys [2] and GaP/InP superlattices [3], and controlled nanoscale crystallization of GaNAs [4]. I will also describe a novel scheme for the design and synthesis of three-dimensional quantum dot crystals.

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