INV-21

Surface morphology and lattice strain in semiconductor nanostructures

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Crystalline strain in nanostructure quantum wires (QWRs) and dots (QDs) is one of the fundamental elements that affect the physical properties of these ultra-small electronic structures. We have used high-resolution synchrotron x-ray diffraction to study the strain in these QWR and QD materials. Constructive interference among the wires or the dots within the coherence width of an x-ray beam produces diffraction satellite peaks around each crystal Bragg reflection. This phenomenon of coherent grating x-ray diffraction (CGXD) enhances the scattering signal from individual wires or dots and increases the strain sensitivity. In addition, the interference within the individual wires or dots gives rise to diffraction patterns related to the spatial distribution of the strain field.

We show an example of such strain and strain-distribution measurements on a series of InGaAs/GaAs(001) QWRs. Our results show a lateral size-dependent lattice distortion that is orthorhombic as opposed to the usual tetragonal as in the case of quantum wells. We also show that the strain is the principle cause for the energy band-gap increase observed on the QWRs, which illustrates the importance of basic structural information in nanostructure science and engineering.