Mechanical breakdown of bent Silicon nanowires imaged by Coherent X-ray diffraction

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Abstract

This talk will present the analytical method of Bragg Coherent X-ray Diffractive Imaging (BCDI) as a method of imaging nanocrystals with extreme sensitivity to strain. The picture below shows the strain field surrounding a dislocation loop, coloured according to the observable phase (in radian units). We have developed a new method called GPER to surmount the difficulty of BCDI to image the structure of strongly strained crystals. We used calculated models from Finite-Element Analysis (FEA) to guide an iterative algorithm to fit experimental data from a series of increasingly bent wires cut into Silicon-on-Insulator films. Just before mechanical fracture, the wires were found to contain new phase structures, which are identified as dislocations associated with crossing the elastic limit. Materials undergo elastic deformation following a linear relationship, as can be nicely illustrated in stress-strain diagrams. However, when the applied external stresses exceed the elastic limit of the material, the linear stress-strain relations does not hold anymore. The elastic limit, where the linear region ends, for single crystalline Silicon is difficult to measure experimentally, and there is currently no consensus on the exact value. One of the difficulties for accurate measurement in semiconductor or metallic materials is that the complex microstructure couples with the anisotropy of elastic modulus, so the elastic limit for specimens of different microstructures of the same material can be different. The results have significant importance in the technological use of strain to modify carrier mobility in modern electronic devices.