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Dynamical x-ray multiple-diffraction effects applied to characterization of real crystals and heterostructures

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So far, multiple-diffraction experiments predominantly have been concerned with either the multibeam Borrmann effect or Renninger scanning. High-resolution multiple Bragg diffraction also is highly structure-sensitive because the wave field pattern in a Bragg-diffracting crystal depends on its angular position within the dynamical diffraction region. To achieve high resolution, it is necessary to collimate the incident beam in two dimensions; therefore, it is desirable to use synchrotron radiation. We used multiple diffraction to study a boron-implanted Si (100) crystal (ion energy 100 keV, dose 10@15 cm@-2, 10-min anneal in oxygen atmosphere at 800C, 000/400/311/111 configuration) and InGaP/GaAs (111) heteroepitaxial structures (film thickness 0.8 and 0.5 mm, 000/111/220 configuration). The Si (100) crystal was studied at Daresbury Laboratory [station 9.3, wavelength 0.11 nm, collimation 2 x 6 arc sec, polar scanning]; InGaP/GaAs was investigated using a conventional x-ray tube [CuKα1 radiation, wavelength 0.154 nm, collimation 15 x 12 arc sec, Renninger-like azimuthal scanning]. The implantation-induced outward displacement of the topmost atomic plane in Si (100) was 0.034 nm. A film-induced multiple-diffraction "pumping effect" in the InGaP/GaAs structures was highly sensitive to the film thickness. Fine dynamical-diffraction effects related to the coupling reflection in the film observed were highly sensitive to the film thickness and deformation, as well as normal and tangential components of the film-substrate misorientation.