Structures of arsenic-deposited silicon surfaces probed with grazing-angle x-ray standing waves at a vertical wiggler synchrotron source

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Structures of As-deposited silicon surfaces are fundamental to the growth of GaAs on Si substrates. We applied the grazing-angle x-ray standing-wave technique to As-deposited Si(111) and Si(100) surfaces in an ultrahigh vacuum environment to explore the accurate in-plane structures of these surfaces. Experiments, made at the wiggler source of the Photon Factory, profited from the vertically polarized synchrotron x-rays to use a horizontal scattering geometry, which facilitated the control of the in-plane and out-of-plane scattering angles with a submicroradian accuracy. Arsenic atoms were found to precisely occupy the threefold symmetry sites on the bulklike Si(111) surface with little disorder. Profile fits of the As emission profiles revealed a displacement from this site no greater than 3% of the Si(-220) lattice spacing. This is consistent with the model indicating As atoms substituting for the Si atoms at the topmost site of the Si(111) double plane. By miscutting the Si(100) surface, we tried to grow single-domain Si(100):As samples, but our RHEED observations always showed mixed 2x1 and 1x2 domains. We collected then two sets of standing-wave data using the orthogonal {220} planes to determine the As-As dimer bond length and the relative domain areas.