Public Abstract

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Graduation Term:WS 2006
Department:Animal Sciences
Degree:PhD
Title:X-RAY DIFFRACTION STUDIES OF THE Pb/Si(111) SYSTEM

This dissertation investigates the structure of the Pb wetting layer on the Si(111)7x7 using X-ray diffraction techniques. It was found that the wetting layer shows a surprising kinetic behavior within the structure over a 200C temperature range. When grown at low temperature (<150C), the wetting layer structure increases its order from an initial deposited structure toward an 8x8 lattice. However, when grown at higher temperatures (>150C), the wetting layer and the Si(111)7x7 transition to a Pb lattice gas on the Si(111)1x1 surface, removing the 7x7 reconstruction. Moreover, the rate of transition also increases with temperature. These kinetic observations resulted in a surface preparation procedure for a stable Pb/Si(111)7x7 wetting layer.
The structure of the stable Pb/Si(111)7x7 wetting layer was solved with X-ray scattering. The samples were prepared and studied in ultrahigh vacuum (in-situ) using synchrotron radiation at the Advanced Photon Source, on the 6IDC beamline. The scattering measurements were a combination of reflectivity, in-plane diffraction, and truncation rod geometries. The structure has two Pb layers along with a modified Si adatom layer. The wetting layer is densely packed, with atoms distributed between bulk Si sites and a lattice of commensurate 8x8 sites. Directly below the wetting layer is a low density, ~6 Pb atom, Pb layer occupying sits directly above Si 7x7 atoms. The 12 atoms in the initial Si 7x7 adatom layer are displaced toward the edges of the unit cell, in the presence of Pb. Moreover, they maintain a 6x6 distance commensurate with the 7x7 unit cell. The structural model proposed here addresses conflicting models that appear in the literature and it solves a long-standing problem that is important to quantum size effect systems.