X-Ray Standing Wave Research

Beamlines: X24A, X25

Technique: X-Ray Standing Waves

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Motivation: Employing x-ray standing waves, under the condition of Bragg diffraction from a perfect crystal, to stimulate a characteristic emission from an adsorbate on or an impurity in the crystal, it is possible to locate its position relative to the crystal lattice with high precision. Using this method in the backreflection geometry relaxes the crystal perfection requirement, and broadens the range of crystals for which the method is applicable. Such studies of atomic and molecular adsorbates on single crystal surfaces are carried out at NSLS on X24A (and, in the past, on X25). Systems which have been studied include those of fundamental physical importance (e.g. simple diatomic molecules adsorbed on close-packed metal substrates) and those of potential technological importance (e.g. the self-assembly and organization of complex organic molecules on metal surfaces).

Results: An elegant application was the investigation of the (1x2) reconstruction of the Cu(110) surface when dosed with a Rb monolayer. A missing-row type structure is formed, and x-ray standing wave data were collected using three distinct Bragg reflections to triangulate the Rb atom position: the (220) reflection to locate the Rb atoms perpendicular to the surface, and the (111) and (200) “inclined” reflections to locate the Rb atoms in the surface. These revealed that the Rb atoms form a one-dimensional lattice gas on the substrate, with perfect registry of the Rb atoms relative to the Cu substrate along the surface normal and in the surface transverse to the rows, but no registry (i.e complete disorder) in the surface along the row direction (see Figure).

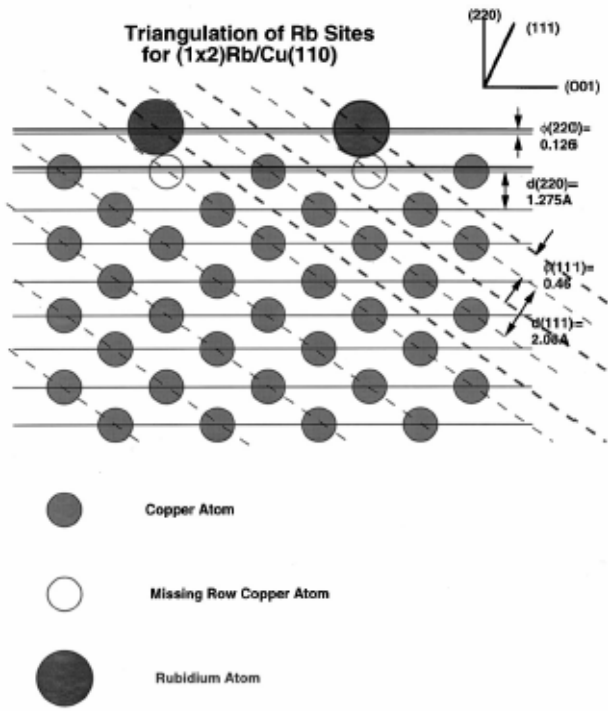

Illustration of the triangulation of the Rb atom position using the (220) and (111) Bragg reflection results. The thin solid and dashed lines represent the (220) and (111) Bragg planes, respectively. The thick solid and dashed lines represent the measured coherent plane positions of the Rb atoms with respect to these Bragg planes. The Rb adsorption sites fall at the intersections of the coherent plane positions. Another measurement using the (200) Bragg reflection (out of the plane of the figure) revealed disorder of the Rb atoms along the (200) direction.