Quick Measurement of Crystal Truncation Rod Profiles in Simultaneous Multi-Wavelength Dispersive Mode

A new method was developed which can simultaneously measure the whole profile of X-ray diffraction and crystal truncation rod (CTR) scattering of interest in a short time (seconds to sub-seconds) without needing to rotate the specimen, detector or monochromator crystal during the measurement. The method uses a bent-crystal polychromator to realize a convergent X-ray beam which has a one-to-one correspondence between energy and direction and a two-dimensional pixel array detector to simultaneously measure intensity distribution of diffracted/scattered X-rays as a function of the momentum transfer.

Crystal truncation rod (CTR) scattering is caused by the sharp truncation of the crystal at the surface and extends to angles far from the Bragg point along the direction of the surface normal of the sample crystal. The amplitude of this CTR scattering is of the same order as that of the scattering from surface monolayers. Atomic coordinations at surfaces and interfaces can be determined by analyzing the interference between these two. In the conventional angle-scan method, the CTR scattering profile is recorded by repeating scattered intensity measurements a few hundred times, each time after changing the incident angle of monochromatized and collimated X-rays. Data collection in the angle-scan mode therefore typically takes several tens of minutes to several hours even when using third-generation synchrotron radiation sources.

Figure 1 shows the geometrical arrangement of the present method. A white X-ray beam is diffracted by a polychromator curved crystal. Since the angle between the incident X-ray beam and the diffracting planes changes continuously along the surface, the energy $E$ (wavelength $\lambda$) of the diffracted X-rays also varies as a function of the beam direction toward the horizontal focus. The convergent X-ray beam components of different energies are incident on a sample placed at the focus in a geometry such that the glancing angle $\varphi$ in the vertical direction is the same and they are diffracted within corresponding vertical scattering planes by a specimen. The momentum transfer defined by $q_z = 4\pi\sin\varphi/\lambda$ continuously varies because the wavelength $\lambda$ changes as a function of direction. The normalized horizontal intensity distribution downstream of the sample represents the reflectivity curve profile both near to and far from the Bragg point.

The present method opens up the possibility of obtaining time resolved CTR scattering profiles from samples undergoing irreversible structural change at surfaces and interfaces. Time-resolved CTR measurement is now under way for samples which undergo photo-induced irreversible surface structure changes.

REFERENCE


BEAMLINE

AR-NW2A

T. Matsushita (KEK-PF)