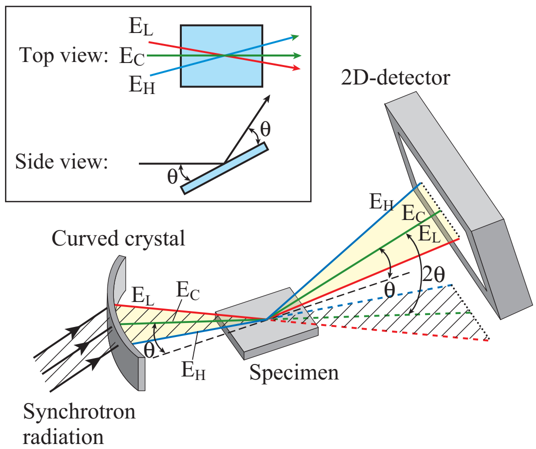
Crystal Truncation Rod Scattering Measurement in the Simultaneous Multi-Wavelength Dispersive Mode: Time-Resolved Measurements and Quick Three-Dimensional Reciprocal Space Mapping

Tetsuroh Shirasawa[1], Etsuo Arakawa[2], Wolfgang Voegeli[3], Toshio Takahashi[1], and Tadashi Matsushita[3]

[1]Institute for Solid State Physics, University of Tokyo, Kashiwa, Chiba, Japan

[2]Department of Physics, Tokyo Gakugei University, Koganei, Tokyo, Japan

[3]Photon Factory, Institute of Material Structure Science, KEK, Tsukuba, Ibaraki, Japan



To observe dynamic structural changes at surfaces and interfaces, we have developed a new method of simultaneously measuring X-ray crystal truncation rod (CTR) scattering profiles without mechanical motion of the specimen, detector and X-ray optics during the measurement. The measurement geometry is shown in the figure. A curved crystal polychromator produces a horizontally convergent X-ray beam having an one-to-one correlation between energy and direction. The convergent X-ray beam components of different energies are diffracted within corresponding vertical scattering planes by a specimen placed at the focus. In the specular geometry, although the glancing and exit angles, θ, are the same for all the directions, the momentum transfer continuously varies because the X-ray energy (wavelength) changes as a function of direction. The normalized horizontal intensity distribution behind the specimen represents the CTR scattering profile.

We have utilized the new method for observing the photo-induced super hydrophilicity of the rutile $TiO_2(110)$ single crystal surface. We will show the time evolution of the CTR scattering profile due to the surface structural change associated with the hydrophobic-hydrophilic transition during the ultraviolet light irradiation.

Another application of the new method is the quick reciprocal space mapping for characterization of surface/interface structures. Since the method is capable of measuring the two-dimentional CTR scattering distribution simultaneously, the reciprocal space map can be quickly obtained which provides abundant structural information about the surface or interface of interest. We will show that the two-dimensional reciprocal space map of a GaAs/AlAs superlattice specimen can be obtained in 1 s with the new method, while it took $\sim$ 30000 s with the conventional angle scan method with monochromatic X-rays. We will also show the three-dimensinal reciprocal space map of the GaAs/AlAs superlattice measured with the new method. A wide range three dimensional map, which requires an enormous data collection time with the conventional method, could be easily and quickly obtained just by rotating the specimen about the surface normal axis.