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

Tetsuroh Shirasawa[1], Etsuo Arakawa[2], Toshio Takahashi[1], Tadashi Matsushita[3], Hidenori Toyokawa[4], Hiroo Tajiri[4]
[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
[4]Japan Synchrotron Radiation Research Institute, SPring-8, Hyogo, Japan

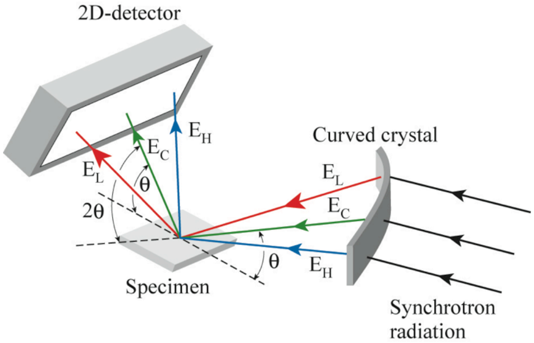

Fig. 1: X-ray optical layout of the simultaneous multi-wavelength dispersive diffractometry.

Aiming for time resolved measurements in the wide q (momentum transfer) range of interest, diffraction and crystal truncation rod scattering profiles are simultaneously measured with no need of sample or monochromator scanning using a geometry shown in Figure 1. Using a curved crystal polychromator, a horizontally convergent X-ray beam having a one-to-one correlation between energy and direction is produced. The convergent X-ray beam components of different energies are diffracted within corresponding vertical scattering planes by a specimen placed at the focus. Although the glancing angle θ is 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 reflectivity around and at far from the Bragg point.

Using a curved crystal (Si 111 reflection), a convergent X-ray beam having an energy range of 7.68~9.30 keV or 16.2~23.0 keV was produced. The scattering intensity distribution from a specimen ($[GaAs(12ML)/AlAs(8ML)]_{50}$ superlattice on GaAs(001) substrate) was measured with a two-dimensional pixel array detector. For 00L reflection (specular geometry), reflected intensity profile was simultaneously measured in the range $3.3<L<4.7$ or $1.6<L<2.4$. Around the 002 reflection. The CTR scattering profile down to reflectivity of $1\text{x}10^{-9}$ was measured with a sufficient exposure time (1,000–3,000 sec). The CTR profile simultaneously measured is quantitatively well reproduced by that measured with the conventional angle-scan XRD measurement using a monochromatized X-ray beam. With 100, 10, 1.0 and 0.1 s exposure times, profiles down to reflectivity of $\sim6\times10^{-9}$, $\sim2\times10^{-8}$, $\sim8\times10^{-8}$ and $\sim8\times10^{-7}$ were measured, respectively. Reflectivity curves were successively and successfully measured with time resolutions of 1.0 and 0.1 s during the rotation of the specimen, demonstrating the time resolving capability of the new method.