Bent Perfect Silicon Crystal Monochromator for Cold Neutrons

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Usually, SANS (small-angle neutron scattering) instruments are installed at an end-guide position because they require rather large space for detection system, very low background and a wide wavelength band of about $\Delta\lambda/\lambda \sim 10\%$. The last condition is not easy fulfilled by using a conventional crystal monochromator and therefore, at present a velocity selector is usually used for such purposes. We are now developing a compact ellipsoidal-mirror focusing small-angle neutron scattering instrument (mfSANS) employing a wide-wavelength band monochromator, and have a plan to install several such SANS instruments along the guide tubes at JRR-3 reactor of Japan Atomic Energy Agency or at many other research reactors. In order to realize such project, we have to develop a wide-wavelength band monochromator for cold neutrons having $\Delta\lambda/\lambda$ of several percents, preferably 10%.

In the case of the mfSANS instrument, we will use a beam entrance collimator of about 1 mm to 5 mm in diameter. When Pyrolitic Graphite (PG) monochromator is used in such a geometry, the $\Delta\lambda/\lambda$ of the monochromator becomes too small, of the order of a few-tenth of percent, irrespective of the mosaic spread of the crystal. Bent perfect crystal (BPC) of Si in the fully-asymmetric diffraction geometry represents a good alternative for realization of such a monochromator with required parameters. However, there are no corresponding data available in the cold neutron region and as far as we know, even for the bent crystal in the symmetric diffraction geometry.

Therefore, we studied neutron optical characteristics of the BPC silicon slabs in the cold neutron region. Unfortunately, we did not have access to a white-neutron beam-port, we used the ULS instrument at the C1-3 port of the cold neutron guide C1 of JRR-3. The instrument has a PG(002) monochromator, which provided us neutrons of about the wavelength of 0.47 nm. First we measured the beam-characteristics from the PG-monochromator using a 5-inch diameter scintillation-counter based on a resistive-wire type photo-multiplier tube. With its very-high positional resolution combined with a fine slit, we could measure the phase-space intensity of the beam, namely, not only the position dependent flux, but also the angular divergences of them.

Knowing the beam parameters from the PG-monochromator, then we put BPC- and in Si(111) slabs on the second axis of the diffractometer for diffraction in symmetric reflection geometry ((111)-crystal planes were parallel to the main face of the crystal slab) and in the non-dispersive setting with respect to the PG(002) monochromator. We made rocking curve measurements with various bending radii in the range of $R>2$ m. First, one BPC Si slab was used, then we repeated the measurements with two and three BPC Si slabs stacked together as a sandwich. We successfully measured 2-dimensional images of reflected neutrons with the position sensitive detector.

At first, with changing the bending radius R from almost infinity to several meters, reflected beam intensity increased without broadening of the rocking curve, which means that the total angular change brought about by bending is smaller than the mosaicity of the PG-monochromator. However, by bending the Si-crystals furthermore, the situation distinctly changed, the peak reflectivity was saturated and broadening of the rocking curve was observed. We also observed reflected inten-

sity enhancements when one or two crystals were added to the sandwich.

In order to check whether we could enhance the wavelength-bandwidth further more, we conducted another type of experiment using the pulsed neutron source of Hokkaido University based on a 45-MeV electron-linac. In the experiment, white cold-neutron beam was incident into several-different positions of the BPC with slightly different angles and the wavelength-shifts were measured using a time-of-flight technique.

Detailed analysis of both experiments is underway.