Performance of YB_{66} Double-crystal Monochromator for Dispersing Synchrotron Radiation

The crystal growth technique of YB_{66} was developed originally by Tanaka and Kamimura's group of the National Institute for Materials Science (NIMS) [1]. YB_{66} has a lattice plane (4 0 0) that is large (0.586 nm) and suitable for dispersing soft X-ray [2], which cannot be covered easily by grating monochromators. Synchrotron radiation technology has developed rapidly and has been introduced as a third-generation light source for the past ten years. Although the problem of a high heat load from third-generation light sources has not yet been overcome in the dispersion by a YB_{66} crystal, a great demand for executing an experiment using a high-resolution and high-brilliance soft X-ray light source still remains. In addition, one of the important specifications of beamline **BL15XU**, which has been developed by NIMS, is the capability of obtaining monochromatic light of optional wavelength on a sample between 0.5 keV and 60 keV. YB_{66} is known to have an energy resolution ($\Delta E/E$) of about 5×10^{-4} and is more resistant to synchrotron radiation damages than other crystals (Beryl, Quartz, InSb) [2] applicable in the same energy region. Thus, the beamline monochromator with YB_{66} is the most suitable for BL15XU [3] at SPring-8, which is a third-generation light source in the 1 - 2 keV range and the first of its kind in the world.

The YB_{66} crystal (10 $mm^H \times$ 20 $mm^V \times$ 1 mm^T) used in this study was a commercial product (Crystal Systems Inc.). The crystal surface which is parallel to a diffracting plane was polished by a lapping machine and by hand. An indirect cooling system using a Ni-coated holder made of Cu was used as shown in Figs. 1(a) and 1(b) [4]. The YB_{66} crystal was set on the holder using liquid InGa after pretreating of the contact surface, ultrasonic washing for 15 min with acetone and preheating for 2 hours at 110°C.

The soft X-ray used in this study was generated by a helical undulator. This type of undulator has the characteristics that higher harmonics distribute mostly outside an axis of X-ray, and thus, the heat load of the crystal due to higher order lights can be reduced to some extent. In this study, the characteristics of synchrotron radiation dispersion from the helical undulator operating at an electron energy of 8 GeV and an injection current of 100 mA were studied. The schematic drawing of the experimental configuration is shown in Fig. 2.

For the estimation of the source condition which dominated the heat load at the crystal surface, thermal analysis by the finite element method was performed. Rocking curves were measured by rotating the $\Delta\theta$ axis of the first crystal, and the photon flux passing through this monochromator was measured by an Si PIN photodiode.

The most suitable energy region for the YB_{66} crystal was the 1 - 2 keV range. It is also possible, but not easy, to use this crystal up to 3 keV or higher, because there are absorption edges of Y (L_1-edge 2373 eV, L_2-edge 2156 eV and L_3-edge 2080 eV). From the results of measurement, the FWHM of the 4 0 0 reflection is plotted as a function of photon energy ranging from 0.15 eV at 1.1 keV to 0.42 eV at 2.1 keV as shown in Fig. 3. The FWHM of the YB_{66} crystal obtained is superior to that obtained at SSRL [5]. The footprint on the crystal at SSRL, 1.5 $mm^H \times$15 mm^V [5], was significantly larger than that obtained by us, 0.07 $mm^H \times$1 mm^V. The effective divergence of our beam originating from the helical undulator being smaller than that of SSRL is the main reason that our FWHM value was superior to that obtained at SSRL.

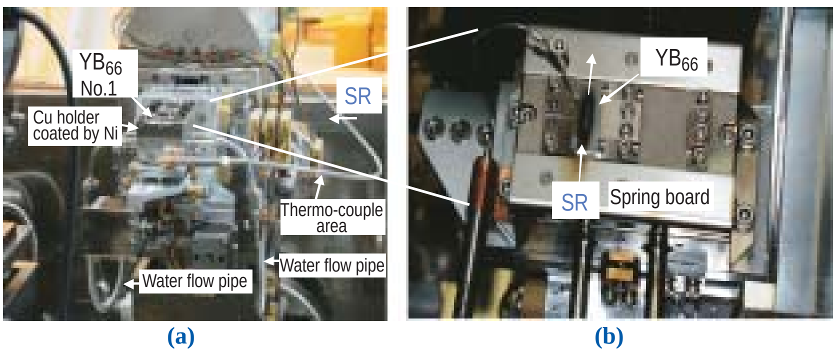

Fig. 1. **(a)** Installation of the YB_{66} crystal on the holder of the monochromator in BL15XU. First, YB_{66} crystal is set on the Ni - coated Cu holder. InGa is placed in the interface between the YB_{66} and Ni-coated Cu holder. A thermo-couple is attached to the front surface of YB_{66}. Ni-coated Cu holder is cooled by water. **(b)** Top view of the YB_{66} crystal. The size of YB_{66} crystal is 10 $mm^H \times$ 20 $mm^V \times$ 1 mm^T. The front surface near the edge was pressed down by two points using the spring board of the holder.

The photon flux passing through the monochromator of BL15XU measured at the sample position at a stored current of 100 mA by a Si PIN photodiode under vacuum is shown in Fig. 4. The photon flux ranged from 6×10^8 photons/sec/100 mA at 1.1 keV to 5×10^9 photons/sec/100mA at 2 keV, almost the same as that obtained at SSRL [5]. Even we attenuated the thermal load from the undulator, a photon flux as high as 10^9 photons/sec/100mA measured at the sample position was obtained.

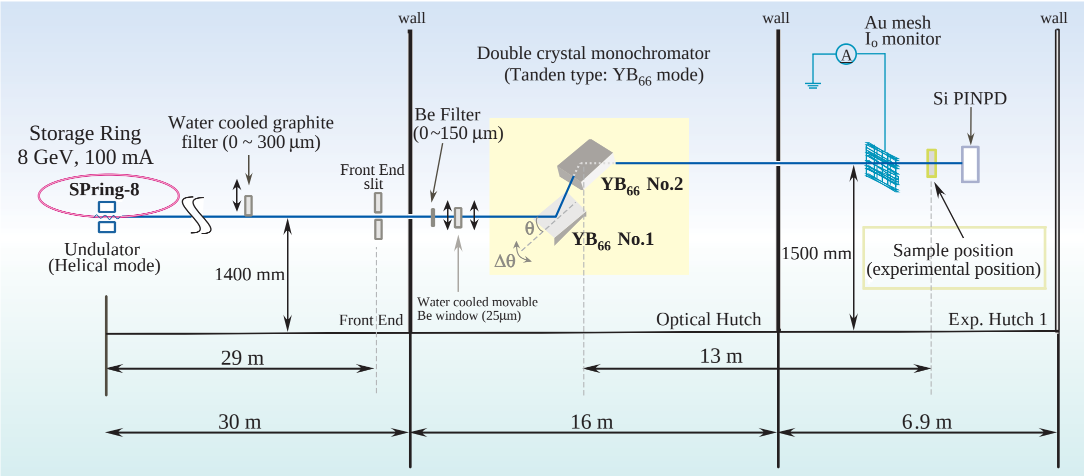

Fig. 2. Outline of the experimental configuration to the first experimental hutch of beamline BL15XU at SPring-8. A tandem type monochromator consists of two monochromators which can select the analyzed crystal from Si, YB_{66}, and multilayer. In the 1 - 2 keV range, we adopted the YB_{66} crystal for dispersing synchrotron radiation.

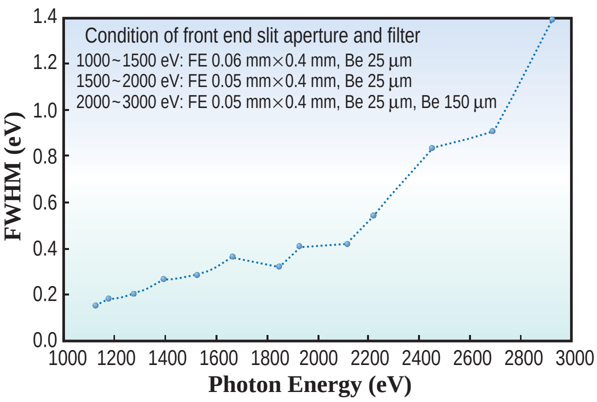

Fig. 3. Energy resolution obtained from the FWHM of the rocking curve of the YB_{66} 4 0 0 reflection as a function of photon energy ranging from 0.15 eV at 1.1 keV to 0.42 eV at 2.1 keV.

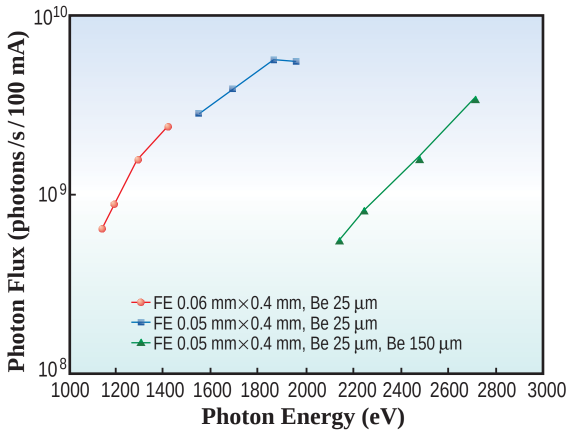

Fig. 4. Photon flux passing through the monochromator at the ring current of 100 mA. It was measured at an experimental position by a Si PIN photodetector as a function of photon energy for the front end slit size and filter conditions as parameters.

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