BL15XU
WEBRAM

1. Introduction

BL15XU, which is officially referred to as WEBRAM (Wide Energy Beamline for Research in Advanced Materials), is the contract beamline of the National Institute for Materials Science (NIMS). The light source of the beamline is a revolver undulator with two sets of magnet arrays, one of which is a planar undulator and the other a helical undulator. A liquid-nitrogen-cooled double-crystal monochromator has been installed into the beamline and provides monochromatic X-rays from 2.2 to 36 keV. Furthermore, a channel-cut monochromator, a focusing mirror system, and a diamond phase retarder system have been installed into the beamline.

FY2020 was the year of the final activities of BL15XU as a contract beamline of NIMS.

2. Beamtime use and publications

The public use of the NIMS beamline is classified into two groups: NIMS researchers and outside users. Research within NIMS includes collaborations with Tokodai Institute for Elements Strategy (TIES). In FY2020, 37 proposals were accepted, whereas in FY2019, 55 proposals were accepted. In FY2020, the number of accepted proposals decreased because of the suspension of SPring-8 user access caused by the COVID-19 pandemic and the difficulty of foreign users coming to Japan. Of the accepted proposals, 25 were for NIMS researchers, including five proposals that were carried out under the TIES project, and 12 were for outside users. Two proposals of outside users were canceled owing to the effect of the COVID-19 pandemic.

The beamtime utilization ratio was 49.6% for HAXPES, 32.6% for thin-film X-ray diffraction, and 17.8% for high-resolution X-ray powder diffraction including X-ray total scattering measurements for pair distribution function (PDF) analysis.

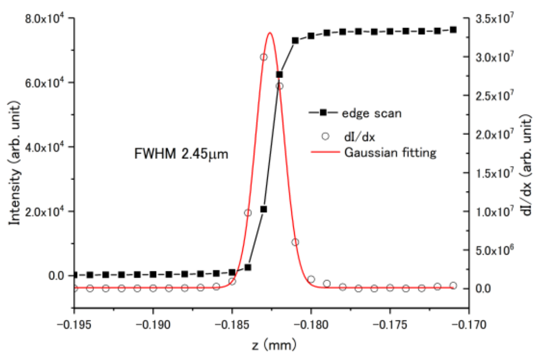
In FY2020, 47 peer-reviewed articles based on research at the beamline were published. This number is slightly larger than that published in FY2019.

3. Improvement of experimental apparatuses

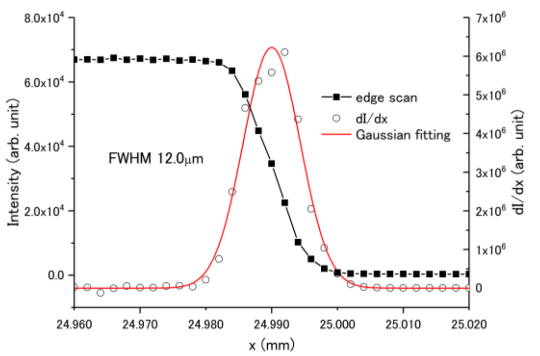
In FY2018, for high-pressure in situ X-ray diffraction experiments at BL15XU, a diamond anvil cell (DAC) diffractometer was installed in collaboration with the High Pressure Group of NIMS. The diffractometer has a rotating oscillation axis for DAC and a flat imaging plate cassette equipped with a positioning system.

In the first year of use of the DAC diffractometer, measurements of the bulk moduli of incompressible superhard materials were only partially successful. Although the diffractometer was able to achieve precise lattice constant measurements under high pressure, the X-ray collimation of the diffractometer was not sufficiently small compared with the sample size in DAC. For high-pressure experiments using the DAC diffractometer, the preferable X-ray spot size at the sample position is less than a 30 μm square. In FY2019, we introduced a microcollimator system to perform more sophisticated diffraction experiments under high pressure in BL15XU.

However, a beam collimated simply by pinholes does not provide a practical beam strength because the total flux is drastically reduced. Since the volume of the compressed sample is very small, a higher incident X-ray flux is required to obtain a higher signal-to-noise ratio for an experiment at higher pressure to be successful. In FY2020, we tried to solve this problem by installing a two-dimensional focusing X-ray refractive lens optimized for 29.2 keV into the DAC diffractometer. A new 4-axis stage was installed to mount the lens in the DAC diffractometer. The focused beam size was evaluated by a knife-edge scan. It was found that the focused beam widths were 2.5 μm in the vertical direction and 12 μm in the horizontal direction at half-maximum (Fig.1).



(a)



(b)

Fig. 1. Beam profile of the focused beam: (a) vertical and (b) horizontal directions.

The intensity of the beam was increased by a factor of 220 and this beam intensity is sufficient for DAC diffractometer experiments. After the installation of the focusing lens, high-pressure experiments with the DAC diffractometer reached a practical level. For example, in the case of rare-earth dodecaboride, sufficient intensity data could be obtained in 2 min after focusing with a refractive lens, compared with 20 min with a 30 μm collimator before focusing. In the case of rare-earth nitrides, it was possible to measure the intensity in about 5 min at a pressure of nearly 130 GPa and to accomplish intensity mapping in the sample chamber of DAC.

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