# BL16XU
# SUNBEAM ID

## 1. Introduction

BL16XU, which is referred to as SUNBEAM ID, together with its sister beamline BL16B2, was built to develop various industrial materials by utilizing the high-brightness beam at the large-scale synchrotron radiation facility in SPring-8. It is operated by the SUNBEAM Consortium, which is a private organization comprising 13 companies* (12 firms and one electric power group). BL16XU and BL16B2 began operations in September 1999, and the beamline use contract was renewed in April 2018. In August 2020, we received an interim evaluation and obtained a "continuation" evaluation result.

X-rays emitted from an undulator are monochromatized, shaped, and converged in an optics hutch. The experimental hutch contains four experimental devices. Figure 1 and Table 1 schematically depict and outline the characteristics of BL16XU, respectively.

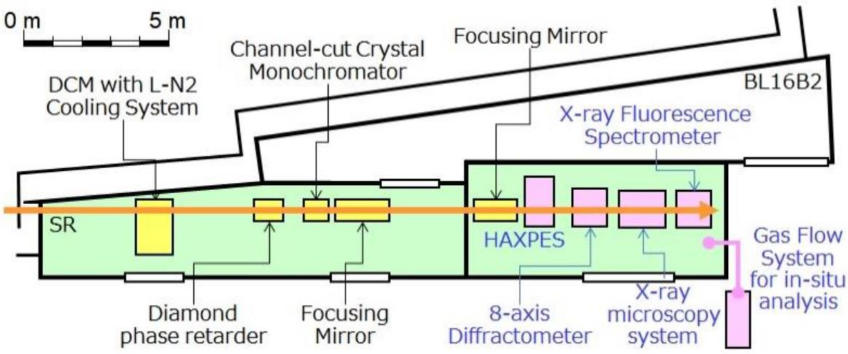


Fig. 1. Outline of BL16XU.

Table 1. Characteristics of BL16XU.

| | |
|---|---|
| Light source | In-vacuo X-ray undulator<br>$\lambda$ = 40 mm, N = 112 |
| Energy range | 4.5–40 keV |
| Energy resolution ($\Delta E/E$) | ~$10^{-4}$ |
| Photon intensity,<br>beam size | ~$10^{12}$ photons/s , < 1 mm x 1 mm<br>~$10^{10}$ photons/s , < 500 nm x 500 nm |
| Beam position stability | ±0.1 mm horizontal<br>±0.8 mm vertical ( 5.0–30 keV) |
| Experimental facilities | HAXPES, XRD, XRF, Microbeam (Microscopy),<br>Gas flow system (corrosive or toxic gas is possible) |

* Kawasaki Heavy Industry, Ltd., Kobe Steel, Ltd., Sumitomo Electric Industries, Ltd., Sony Corp., Electric power group (Kansai Electric Power Co., Inc., Central Research Institute of Electric Power Industry), Toshiba Corp., Toyota Central R&D Labs., Inc., Nichia Corp., Nissan Motor Co., Ltd., Panasonic Corp., Hitachi, Ltd., Fujitsu Laboratories Ltd., Mitsubishi Electric Corp.

**2. Utilization**

Figure 2 shows the utilization of BL16XU in the past decade. The vertical axis shows the proportions of users, excluding the tuning and studying of the beamline itself. The upper graph depicts the utilization by field. The application fields are mainly semiconductors, batteries, and materials. In recent years, research related to green innovations, such as lithium-ion batteries, fuel cells, SiC, and GaN, has been progressing.

The lower graph shows the utilization of equipment (technology). The utilization of HAXPES equipment, which was installed in 2014, is increasing. HAXPES is mainly used for semiconductors and battery materials.

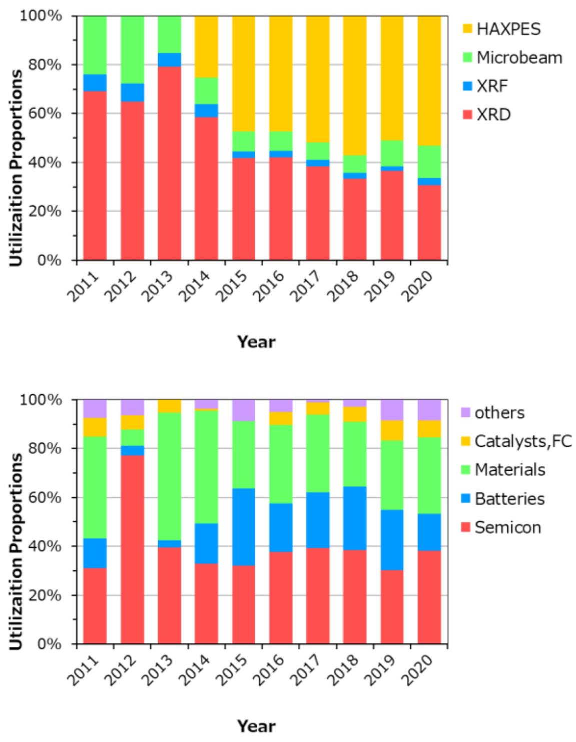


Fig. 2. Relative utilization times of BL16XU in the past decade.

**3. Topics in FY2020**

Below, the research and upgrades conducted in 2020 are described.

**3-1. Construction and advancement of imaging optics experiment**

At the BL16XU microbeam formation experimental equipment, where only the condensing optical system was used, experimental equipment for the imaging system has been removed. Figure 3 shows a schematic diagram of the optical system of the imaging system. We have made improvements by changing window materials and using diffusers.

In the micro–CT image measurement, it was confirmed that the optical system of the X-ray microscope had a magnification of 10.3 times and an effective pixel size of 0.126 μm, achieving a sub-μm resolution. Figure 4 shows the results of the acquired 2D XAFS. This measurement took 800 s, which was a reduction to less than 1/1000 of the time required for a similar measurement in a condensing optical system. It is expected to be applicable to various industrial materials.

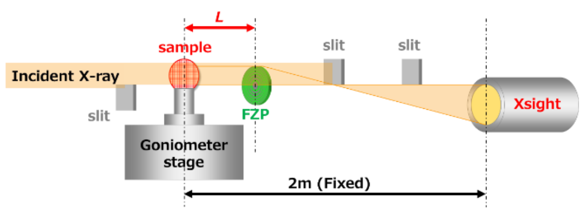


Fig. 3. Schematic diagram of the optical system of the imaging system.

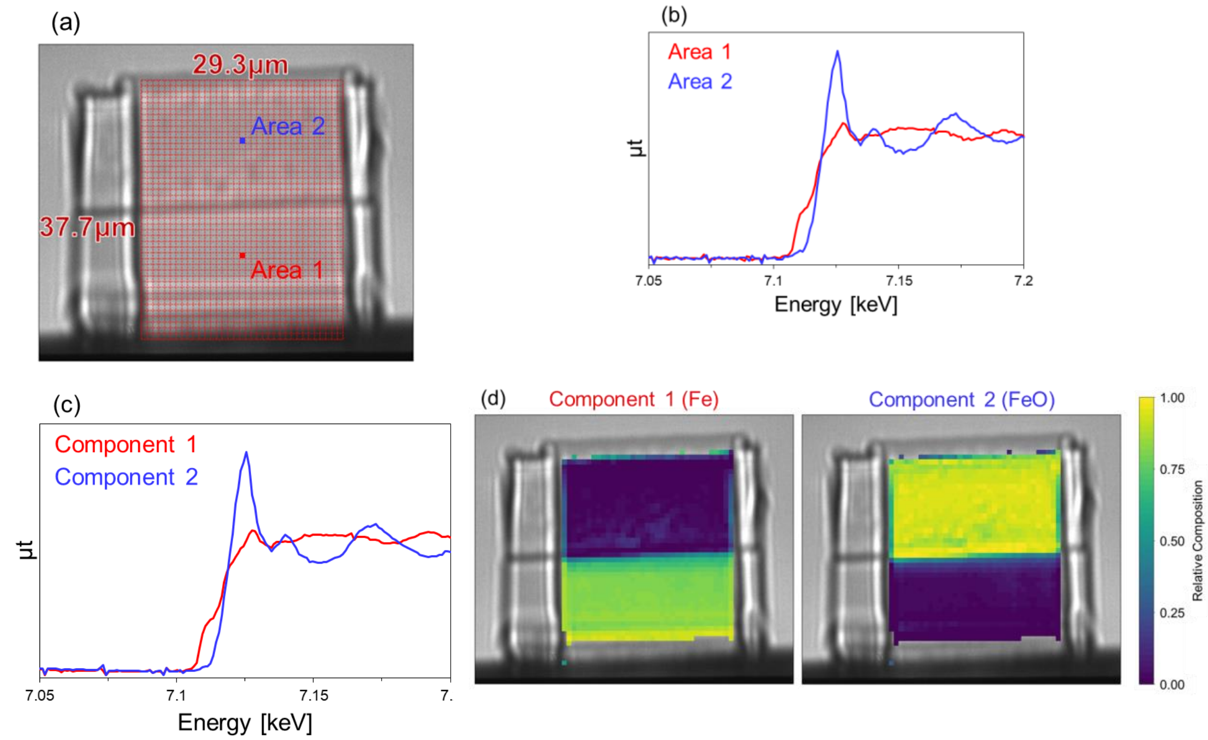


Fig. 4. (a) Enlarged image of the laminated film of Fe and Fe oxide imaged by the imaging optical system of BL16XU. (b) XANES spectra of Areas 1 and 2 in (a). (c) Two component spectra extracted by SO-NMF. (d) Intensity distributions of Fe and FeO obtained from the two components extracted by SO-NMF.

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