BL19B2 Engineering Science Research

BL19B2 is a medium-length hard X-ray bending magnet beamline designed for engineering science researches. Target of this beamline is to promote the use of the synchrotron radiation in the industrial users. The main techniques on this beamline are X-ray absorption, diffraction, scattering, and imaging.

The beamline has three experimental hutches. The first experimental hutch is located at 51 m from the source and has sizes of 4 m (along beam) × 3 m (W) × 3.3 m (H). The second and the third experimental hutches are located at 77 m and 111 m from the source and have sizes of 5 m (along beam) × 4 m (W) × 3.3 m (H) and 8 m (along beam) × 4 m (W) × 3.3 m (H), respectively. Basic experimental equipments for XAFS measurement, a multi-axis diffractometer and a powder diffractometer, and a imaging equipments are prepared in the first, the second and the third experimental hutches.

Area of research

XAFS in wide energy region

Residual stress measurement, Structural analysis of thin film, Surface, Interface

Powder diffraction

X-ray imaging

Keywords

Scientific field

Local structure analysis, X-ray diffraction, Grazing incidence X-ray Scattering, CTR, Reflectmetry, Structural analysis, X-ray imaging

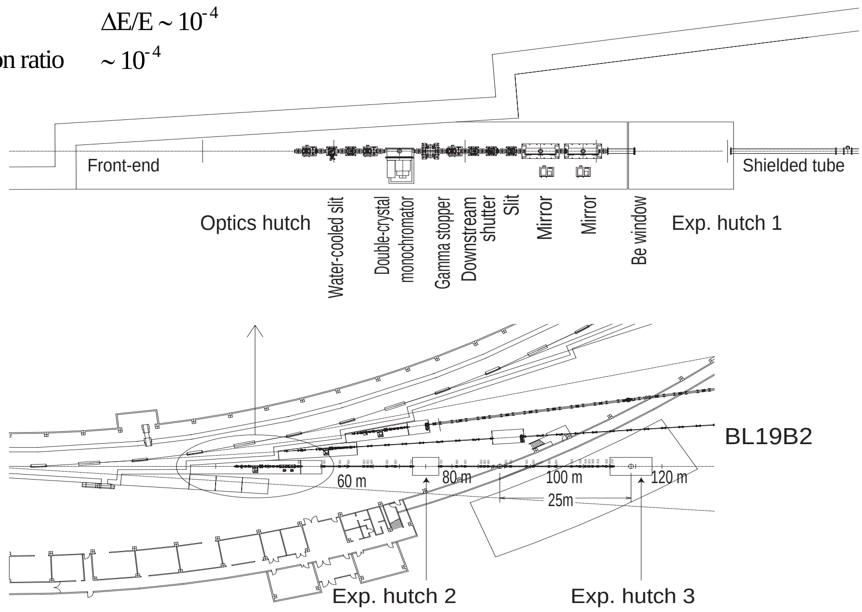
Equipment

Ionization chambers, Lytle type detector, Germanium single-element solid state detector (Ge SSD), Silicon drift-chamber detector (SDD), Multi-axis diffractometer, Debye-Scherrer camera, High and low temperature gas flow instruments, Imaging Plate, X-ray camera, Beam monitor, Zooming tube, CCD camera

Source and optics

X-rays at sample

Tunable energy range	5 ~ 100 keV
Horizontal beam divergence	1.4 mrad
Photon flux	~ 10^9 photons/s
Energy resolution	$\Delta E/E$ ~ 10^{-4}
Higher harmonics rejection ratio	~ 10^{-4}



A schematic views of the beamline optics and experimental hutches

Experimental stations

XAFS

The instruments of XAFS measurement including X-ray absorption measurements in transmission and fluorescence modes were set in the first experimental hutch. The standard XAFS measurement is a transmission mode using ionization chambers (Fig.1). Three lengths of the ionization chambers, *i.e.*, 65, 170 and 310 mm, were prepared. A current of the ionization chamber is amplified to a voltage, converted to frequency, and counted. For the gas-flow type ionization chambers, four kinds of gas, *i.e.*, helium, nitrogen, argon, and krypton, and their mixture gas were prepared. For the fluorescence XAFS measurement, a Lytle type detector, a germanium single-element solid state detector (Ge SSD), and silicon drift-chamber detector (SDD) were prepared. The Lytle type detector has an aluminum solar slit and a 50-mm-long ionization chamber. The element of the Ge SSD has an effective area of 200 mm^2 and a thickness of 10 mm enabling to detect more than 95% incident X-rays. The element of the SDD has an effective area of 5 mm^2 and a thickness of 0.3 mm. The SDD can be operated without liquid nitrogen. A pulse motor driven XZ stage was prepared for sample position adjustment. The step is 0.002 mm per pulse for both axes. A θ - 2θ stage was mounted on the XZ stage for XAFS measurements under a low glancing angle arrangement. The step is 0.0002 degrees per pulse for both axes. X-ray optics is controlled with a personal computer through a beamline workstation. The measurement facilities in the first experimental hutch are also controlled with this computer.

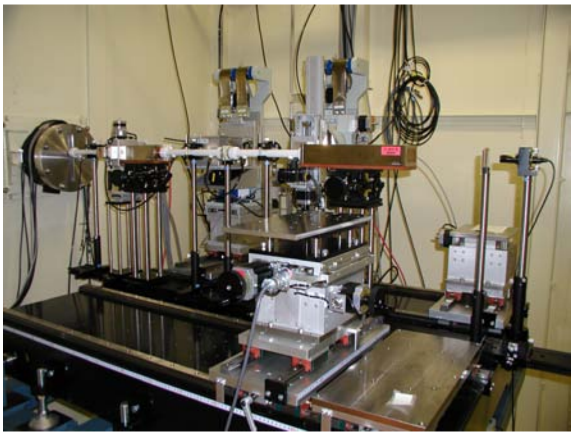


Fig.1. The standard XAFS measurement is a transmission mode using ionization chambers.

Powder diffractometer

The Debye-Scherrer camera is installed at the second experimental hutch in order to perform the accurate structure analysis by powder diffraction study (Fig.2). The camera is the same design of the Debye-Scherrer one installed in BL02B2. The operation system is also same as that in BL02B2. The camera with radius of 286.5 mm has an Imaging Plate (IP) on the 2θarm as a detector. The pixel size of IP can be selected from 50 μm to 100 μm. The high-energy beam with high flux allows us to collect much more Bragg reflections with high counting statistics from a little amount of powder specimen. By using high energy X-rays, it is not necessary to take into consideration the effects of absorption even for the materials involving heavy elements such as rare-earth metals. These will make it possible to measure high quality powder diffraction data of crystalline materials.

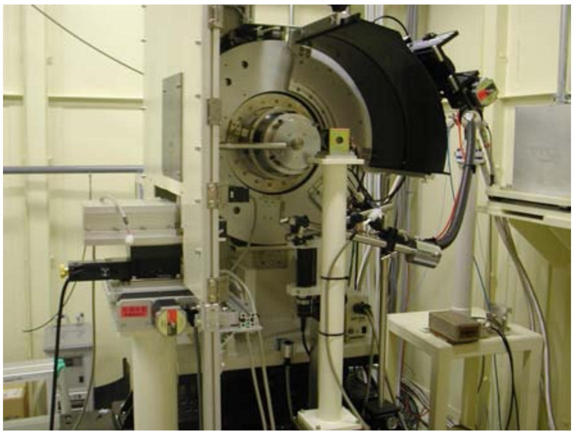


Fig.2. Debye-Scherrer camera

Multi-axis diffractometer

The Huber multi-axis diffractometer installed BL19B2 is composed of conventional four circle goniometer (χ, φ, ω, 2θ) and additional four axes (2θz, θz, ωa, 2θa) (Fig.3). The diffractometer is controlled by SPEC and GUI program. This diffractometer is being tuned for residual stress measurement, structural analysis of thin film, surface, and interface. The Eulerian cradle with a gap within χ-circle is adopted to cover wide scattering angle from - 45° to 160° without blind region for residual stress measurement. Precise linear X, Y, and Z stages (70 mm × 70 mm × 25 mm) on φ axis enable to observe three-dimensional residual stress profiles of bulky sample. It is expected that residual stress in inner region of bulky sample could be observed with using high energy X-rays. Blades of slits made of Ta can eliminate high energy X-rays less than 100 keV. The ωa and 2θa axes are equipped to use an analyzer crystal. The two additional axes ωz and 2 θz are very useful to control glancing angle and take off angle of X-rays to sample surface. In-plane crystallographic structure of thin film can be easily observed by glancing-incidence X-ray scattering. CTR and X-ray reflectmetry are also available.

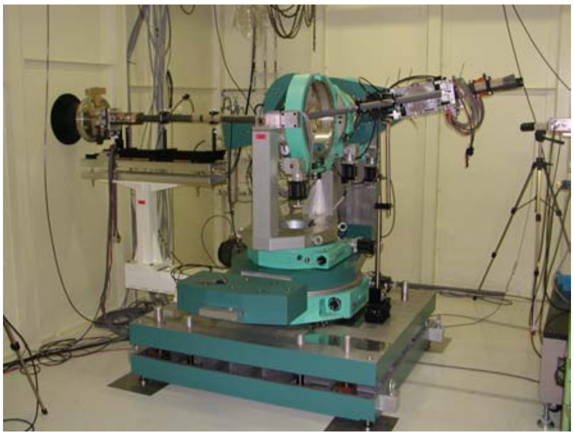


Fig.3. Multi-axis diffractometer

X-ray imaging camera

Two types of X-ray imaging camera are installed at the third experimental hutch located at 110m from the source in the annex west. One is constructed with a CCD camera (Hamamatsu Photonics, C4880-50-24A) and a beam monitor (Hamamatsu Photonics, BM2, Fig.4). Beam monitor is a kind of X-ray to visible light converter and it includes the thin phosphor screen and optical lens. And the other is constructed with a CCD camera and Zooming tube (Hamamatsu Photonics, C5333, Fig.5). Zooming tube is a kind of X-ray to visible light converter. These cameras are used for evaluation of industrial materials by X-ray imaging, e.g. refraction imaging, absorption imaging and topography.

Alignment of specimen and camera is carried out with motorized stages (x, y, z, Rx, Ry and Rz for specimen and x, y and z for camera).

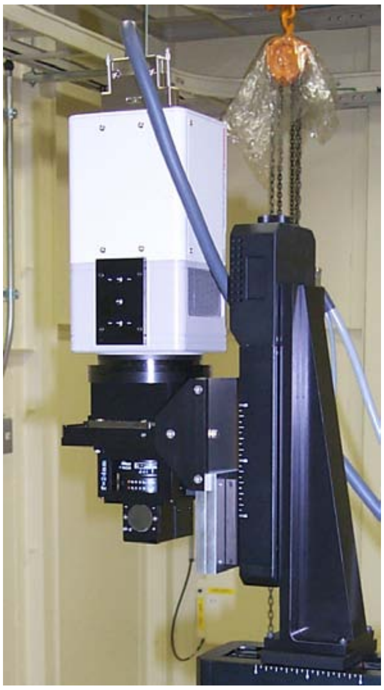


Fig.4. CCD camera and beam monitor

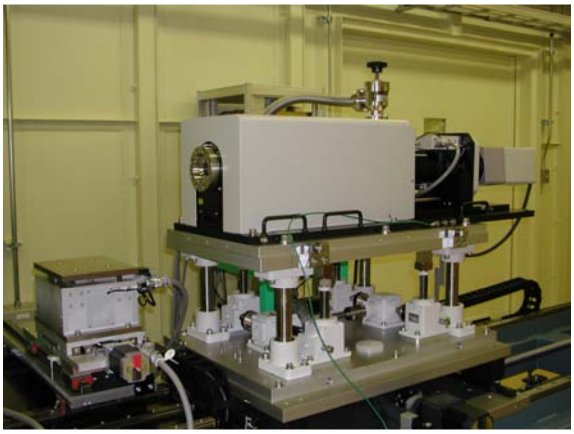


Fig.5. CCD camera and zooming tube

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