BL47XU R&D (1)

An X-ray undulator beamline is allocated to the first 'R&D beamline' which is to serve both scientific and technical R&Ds for the novel utilization of X-ray undulator beam, especially in the hard X-ray region. The missions are R&Ds for novel optics, various imaging techniques and their applications.
Double crystals are both cooled by liquid nitrogen.

Area of research

R&D
Microtomography
Microbeam

Keywords

Scientific field

R&D, Microimaging, Microtomography, Microbeam

Equipment

Free-spaced experimental hutch, Beam monitor, Fresnel zone plate, Silicon drift detector, Clean booth

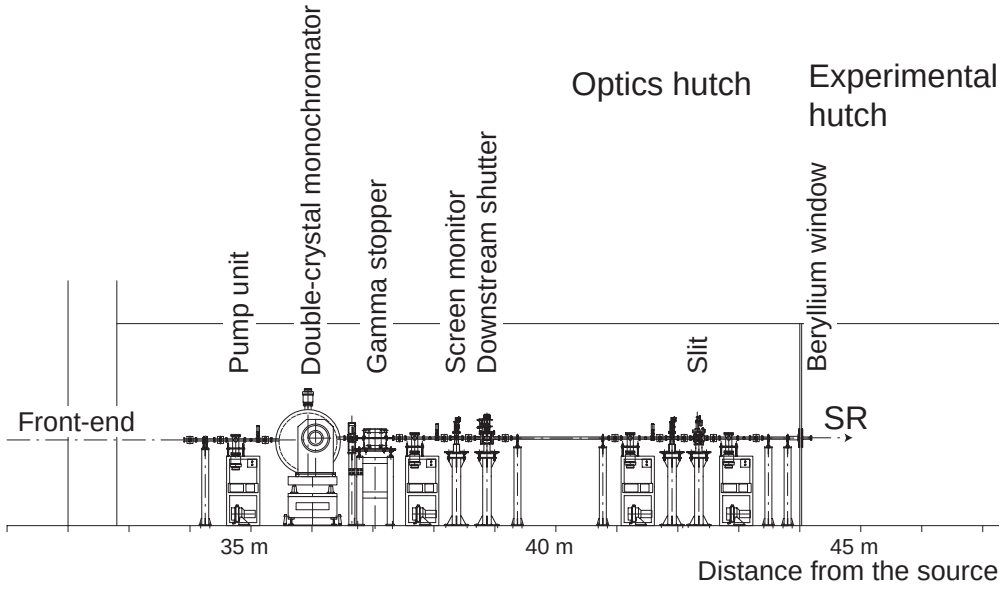
Source and optics

X-rays at sample

Energy range	5.3 ~ 37.8 keV
Energy resolution	$\Delta E/E \sim 2 \times 10^{-4}$ (@E = 18 keV)
Photon flux	4×10^{13} ph/s (@E = 18 keV, @100 mA)
Beam size (FWHM)	1.2 mm (H) × 0.3 mm (V) (@E = 18 keV, @40 m from source)

Experimental stations

Two hutches (experimental hutch 1 and 2) are available. Location of these hutches is shown in Figure 1. A clean booth for the sample preparation is located outside of the experimental hutch 2.



Schematic view of beamline

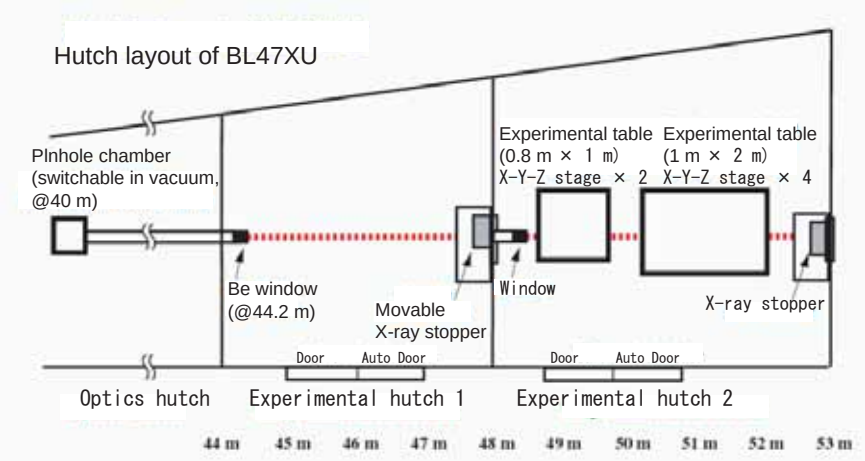


Fig.1. Hutch layout of beamline

Experimental hutch 1 (EH1)

Inside the EH1 is free-space for various uses. The cubic capacity of the hutch is about 3.5 m × .5 m × 3.3 m (height) and the size of the door is about 1.96 m (width) × 2.28 m (height). Users can install every optical equipment for their purpose. A versatile experimental table (1 m × 1 m × 0.9 m (height)) and a pulse-motor controlled X-Y-Z stages are also available. The resolution of the each stage is 2 μm/pulse. When the EH1 is not used, a helium path is installed in order to prevent the decrease of X-ray flux for the EH2.

Experimental hutch 2 (EH2)

There are two experimental tables. The schematic diagram of the arrangement of two tables is shown in Fig.1. On the upstream table, there are two X-Y-Z stages. On the downstream table, there are four X-Y-Z stages. These stages are driven by each pulse motor. For example, the resolution of the X-Y-Z stages is 2 μm and 0.08 μm/pulse in the Y-Z direction and X direction respectively at full step mode. For general purpose, we have 4-jaw slit, solid-state detector, scintillation counter, ion chamber, He-Ne laser, X-ray cameras (middle resolution: pixel size 6 μm and high resolution; pixel size 0.5 μm), and data acquisition system. A pinhole chamber (pinholes and slits are switchable in vacuum at a distance of 40 m from light source) has been installed in the optical hutch.

X-ray microtomography

Upstream table is normally used for the X-ray microtomography system consists of sample stage and image detector stage. Air-bearing type sample rotation stage is used. The wobbling accuracy of the sample rotation stage is less than 0.2 μm. A visible-light converted type image detector (called as Beam Monitor) is used as data acquisition. The spatial resolution is about 1 μm. The maximum field of view is about 1 mm × 1 mm. It takes about 2-3 hours for one CT scan.

Microbeam (Scanning microscopy)

Downstream table is normally used for the microbeam experiment. A Fresnel zone plate is used as the focusing device. Prove size is 0.5 μm (vertical) × 0.3 μm (horizontal), and the focal depth is about 1 mm. Useful energy range is 7~15 keV. X-ray flux of the prove is about 10^9 photons/s in maximum. Ionization chambers and silicon drift detector (SDD) are prepared as the detector.

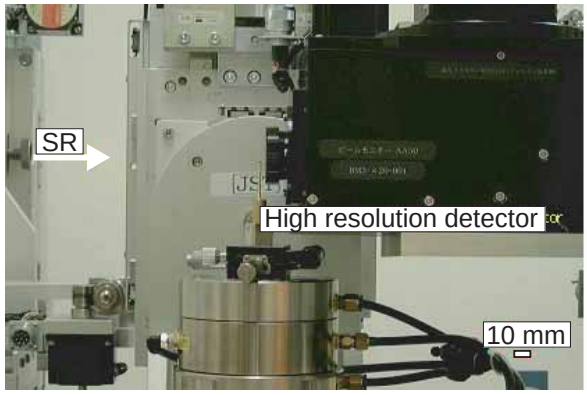
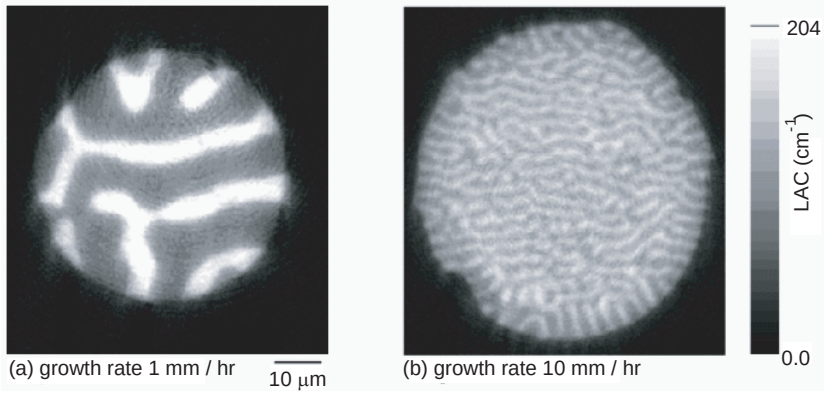


Fig.2. X-ray microtomography setup

Fig.3. X-ray scanning microscopy setup

Sample data 1

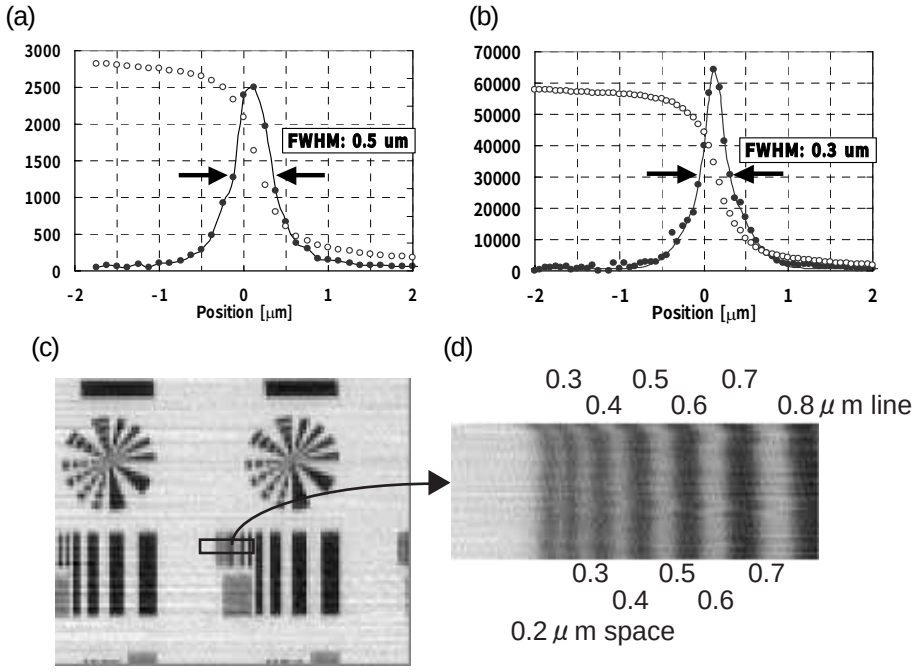
The computer tomographic (CT) images of Sn-Pb eutectic alloys with different growth rates are shown. The micrometer-resolution structures were successfully observed with the system. Bright and dark areas correspond to Pb-rich and Sn-rich phases, respectively. These figures also show that the system had spatial resolution of at least a few microns. X-ray energy was 29.1 keV. The number of projections was 360 for 180 degree rotation. The exposure time for one projection was 2.0 second. The slice thickness was 0.2 μm.



Sample data 2

Figures (a) and (b) show intensity profiles of focal prove of X-ray microbeam in vertical direction and horizontal direction, respectively. X-ray energy; 8 keV. Focusing device; Fresnel zone plate (NTT-AT), material; Ta, thickness; 1 μm, outermost zone width; 250 nm.

Figure (c) shows a scanning X-ray microscope image of a Ta test pattern (scan pitch 1 μm), and its finer scan image (scan pitch 62.5 nm) is shown in (d). Image of 0.2 mm space is clearly resolved.



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