BL29XU
RIKEN Coherent X-ray Optics

1. Introduction

BL29XU is a 1-km-long beamline, where the light source is a standard undulator with a length of 4.5 m. This beamline consists of an optics hutch and four experimental hutches. Various R&D projects are performed on the instruments in the front-end and transport channel sections, such as the double-crystal monochromator, the higher-harmonic-rejecting double mirrors, the TC slits, and the beryllium windows. Intensive studies have reduced the vibration of the double-crystal monochromator. The downstream mirror, which rejects higher harmonics, contains two strips of parabolic mirrors with a focal length of approximately 48 m. This is equal to the distance between the mirror and light source. The glancing incidence angle can be set to 5 and 3 mrad. This mirror also contains a strip of a flat mirror. The parabolic mirrors can provide a parallel X-ray beam by reflecting X-rays emitted from the source, which is approximately 48 m upstream. By reflecting 8-keV X-rays on a parabolic mirror with a 5-mrad incidence angle, the measured vertical angular divergence is reduced from 9 μrad without mirrors to 0.4 μrad [1].

2. Recent activities

Research at BL29XU pursues the most advanced use of coherent X-rays such as coherent X-ray diffraction imaging (lens-less X-ray microscopy) and total reflection mirror optics with ultimate precision.

Y. Taira, a visiting scientist of the SR Imaging Instrumentation Team, developed a high-energy imaging sensor using a $Gd_3Al_2Ga_3O_{12}$:Ce scintillator (Fig. 1). This sensor is composed of a scintillator (thickness switchable among 250, 500, and 750 μm), a lens-coupled optical system, and a CMOS camera. The sensitivity and the modulation transfer function of this sensor were evaluated using 90-keV and 120-keV X-rays. The undulator gap was set to 8.98 mm with first-order harmonics of 5 keV. The first-order reflection from the Si(111) monochromator was set to 30 keV, which corresponds to the sixth-order harmonics. A harmonic separator with a diamond prism extracts 90-keV and 120-keV X-rays reflected from Si(333) and Si(444) planes. A high sensitivity was obtained for the use of these X-rays.

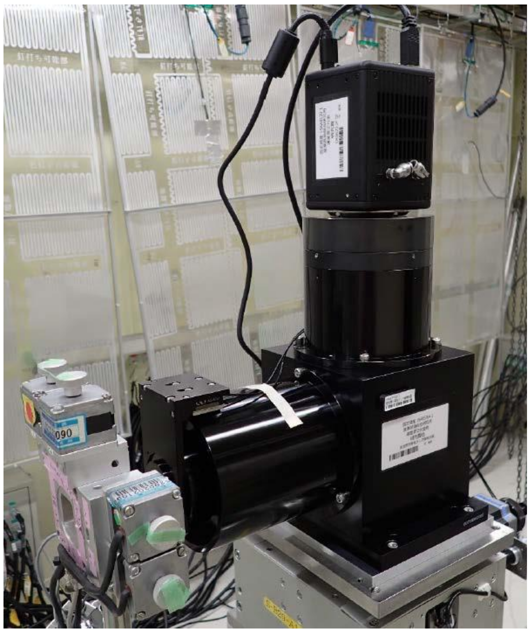

Fig. 1. Photograph of the high energy imaging sensor.

The modulation transfer function of this camera was measured using a slit with a width larger than ~40 μm (Fig.1). A more careful angular alignment of the slit will remove the measurement limitation with a narrower width. Additionally, the spatial resolution of this detector will be further optimized by choosing an appropriate thickness of the GAGG scintillator.

Research at BL29XU has achieved advanced scientific results in the fields of coherent X-ray imaging. The achievements are briefly summarized below.

The collaboration team of Y. Takahashi, Tohoku Univ., demonstrated multibeam ptychography using synchrotron hard X-rays. This technique can enlarge the field of view of the reconstructed image of objects by efficiently using partially coherent X-rays. Using three mutually incoherent beams, they successfully reconstructed the phase map of the samples at a spatial resolution of 25 nm in a field of view with a width double that in single-beam ptychography [2].

T. Hoshino, a member of the SR Imaging Instrumentation Team, used X-ray photon correlation spectroscopy (XPCS) to study the dynamics of polyvinyl acetate near its glass transition temperature. They determined the local shear rate and calculated the dynamical heterogeneity. They clearly observed the rapid change of dynamical heterogeneity near the glass transition using an XPCS measurement with tracer particles [3].

Yoshiki Kohmura

SR Imaging Instrumentation Team, Physical and Chemical Research Infrastructure Group, Advanced Photon Technology Division, RIKEN SPring-8 Center

References:

[1] D. Takei et al., *Journal of Synchrotron Radiation*, 23, 158 (2016).

[2] M. Hirose et al., *Optics Express*, 28,2 (2016).

[3] T. Hoshino et al., *Phys. Rev. Lett.*, 124,118004 (2020).