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, higher-harmonic-rejecting double mirrors, transport channel slits, and 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 the light source. The glancing incidence angle can be set to 5 and 3 mrad. The downstream mirror also contains a strip of a flat mirror. 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.

2. Recent activities

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

"CITIUS", a high-speed integrating-type detector for future synchrotrons and XFELs, has been developed by the RIKEN detector group and has a maximum count rate of 30 Mega (in the normal mode) to 600 Mega (in the extended mode) counts per second per pixel at 12 keV by implementing a novel charge-integrating architecture [1]. The initial performance of this detector was intensively evaluated at BL29XUL. The resulting data showed an increment from up to around 945 Mega, upgraded from 700 Mega last year, counts per second per pixel at 10 keV, which is beyond the limit of state-of-the-art photon-counting detectors. The increasing number of user groups demonstrated their scientific measurements with the CITIUS detector. A steady procedure is built where a reliable initial calibration of CITIUS is performed by user groups using BL29XU, and scientific data are acquired at their home-ground beamlines, namely, the X-ray photon correlation spectroscopy group at BL40XU, the spectroscopic imaging group at BL36XU, and the quasi-elastic scattering group at BL35XU.

It is time-consuming to set or remove the vacuum pipes in all four experimental hutches when the experimental hutches need to be switched owing to the user's experimental plans. The first part of the upgrade to simplify these works was conducted where new very light pipe holders with fixed height were introduced in experimental hutch 2. The second part of the upgrade is planned for next year to electronically control the open and close status of the vacuum valves.

Research at BL29XU has produced advanced scientific results in the field of coherent X-ray imaging and ultimate total X-ray reflection mirrors. The following briefly summarizes the achievements.

The collaboration team of C. Song at POSTEC__university in Korea succeeded in obtaining 3D structures of chromosomes at tens-of-nanometer resolution by cryogenic coherent diffractive X-ray imaging. The structures of chromosomes are preserved under frozen-hydrated conditions. The experiment clarified a random distribution of electron density without characteristics of high-order folding structures [2].

The collaboration team of Y. Takahashi, Tohoku University, utilized hard X-ray ptychographic EXAFS measurements to visualize a heterogeneous phase/structure distribution in the bulk of spinel lithium nickel manganese oxides to maximize the performance and stability of the cathode materials of lithium-ion batteries. They could classify the three-phase group in terms of different elemental compositions and chemical states in the oxides [3].

The international collaboration team of Y. Kohmura, SR Imaging Instrumentation Team, RIKEN SPring-8 Center, and Y. Hwu, Academia Sinica, demonstrated X-ray lightsheet microscopy for the first time, which achieved the in-depth resolution of 70 nm, close to the lightsheet thickness by 1D focusing using a Wolter type-I total reflection mirror. By introducing 10-nm-size scintillating nanoparticles and scanning the specimen, three-dimensional super-resolution imaging with isotropic spatial resolution can be achieved [4].

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