BL08W
High Energy Inelastic Scattering

1. Introduction

BL08W is dedicated to high-energy inelastic scattering research. It delivers the highest-energy X-rays emitted from the wiggler at SPring-8. Several research fields, including Compton scattering, high-energy X-ray diffraction, and high-energy X-ray fluorescence analysis, use this beamline. This beamline supports three Compton scattering methods. The first is magnetic Compton scattering, which is used for magnetic materials. The second is high-resolution Compton scattering with a high-momentum resolution of 0.1 atomic units, which is used to study electronic structures and fermiology. The third is Compton scattering imaging (CSI). In addition, the beamline can be used for structural studies of disordered materials by pair distribution function analysis using high-energy X-ray diffraction and studies of cultural properties using high-energy X-ray fluorescence analysis.

In the FY2018 annual report, a CSI technique with a two-dimensional (2D) detector was reported. In FY2019, a new CSI technique with an energy-dispersive 2D detector was developed.

2. Development of Compton scattering imaging with the energy-dispersive 2D detector

Compton scattering is characterized by its high sensitivity to light elements and low-density materials such as gases. Since Compton scattering measurements do not require X-ray transmission through an object, they are advantageous for examining the surface layers of a large object that X-rays cannot transmit. The intensity of the Compton profile provide information about the density, while the shape of the Compton profile give information about the composition.

Two experimental setups for CSI have been performed at BL08W: point-by-point and plane-by-plane. In the point-by-point setup [1], nine Ge solid-state detectors (Ge-SSD) are arranged to record the Compton scattered X-rays through a collimator, which focuses on a single volume of the sample. Since this method has a high energy resolution due to the Ge-SSD, compositional changes of a sample under processing can be studied. However, this method requires moving a sample to obtain a 2D raster slice image.

In the plane-by-plane setup, Compton scattered X-rays through a pinhole are detected by a 2D detector, which is composed of an image intensifier (I.I.) and a CCD camera. This method is easily set up and provides cross-sectional images. However, it cannot provide the shape of the Compton profile because it cannot measure the energy spectra.

To overcome this limitation, we developed energy-dispersive CSI with the plane-by-plane setup. The new CSI setup uses HEXITEC instead of I.I. as the detector. HEXITEC is an energy dispersive 2D detector developed by Quantum Detectors, UK. This detector, which has an 80 × 80 array of 250 μm pixels, can collect the Compton profile from the sample at each pixel. Hence, 2D maps of the intensity and shape of the Compton profile can be constructed. Figures 1(a) and (b) show a schematic depiction and a photograph of the new CSI arrangement, respectively. The pinhole is parallel to the incoming X-ray beams. Because the distance between the sample and the pinhole can be changed automatically with a motor stage, the spatial resolution can be varied. Furthermore, the distance between the pinhole and the detector can be changed to adjust the magnification ratio of the CSI. The pinhole size is 100 μm, which corresponds to the minimum spatial resolution of the CSI.

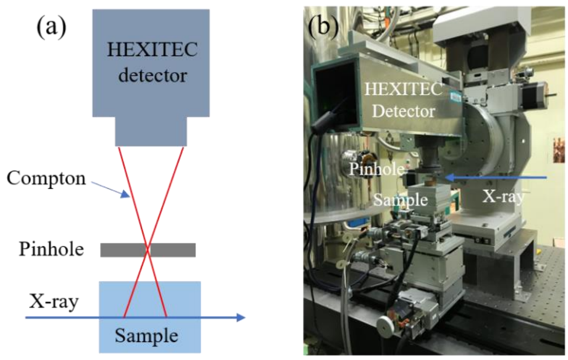

Fig. 1. (a) Experimental setup (side view) and (b) photograph of the arrangement of the new CSI setup.

To demonstrate the capability of the new CSI with the energy-dispersive 2D detector, this method was applied to an 18650-type lithium-ion cell (model MH1) made by LG Chem. The CSI data of the sample were acquired at 165 points. The exposure time was 5 min at each point. Figure 2(a) shows the total energy spectra summed over all pixels. In addition to the two Compton peaks around 115 keV and 230 keV, elastically scattered X-rays (115 keV) and fluorescence X-rays of Pb, W, Cd, and Te were observed. Figure 2(b) shows the CSI data at one point, which was obtained by integrating the Compton profile at 115 keV at each pixel. Figure 2(c) shows a cross-sectional image of stacked CSIs from 165 points. Anodes, cathodes, collectors, and separators were clearly observed.

The S-parameter analysis for the new CSI that enables the visualization of the Li composition in the sample will be reported in the near future.

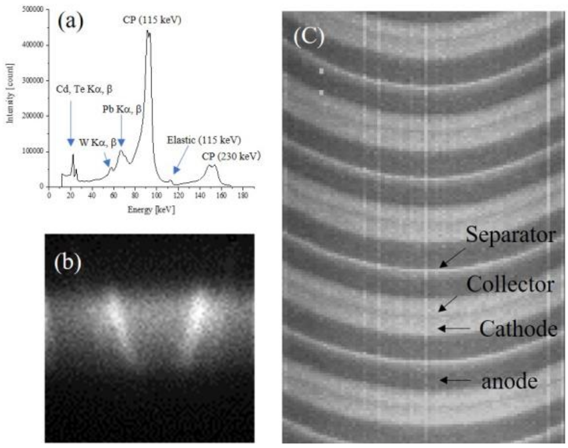

Fig. 2. (a) Total Energy spectrum, (b) CSI at one point, and (c) cross-sectional image of stacked CSIs.

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Reference:

[1] M. Itou, Y. Orikasa, Y. Gogyo, K. Suzuki, H. Sakurai, Y. Uchimoto, Y. Sakurai, *J. Synchrotron Rad*. **22**, 161-164 (2015)