BL14B1
QST Quantum Dynamics II

1. Introduction

BL14B1 is designed for various types of diffraction experiments and X-ray absorption fine structure (XAFS)-type spectroscopy measurements in the energy ranges of 5–90 keV for monochromatized beams and 5–150 keV for white beams. The main optics refers to the standard SPring-8 bending-magnet system with two mirrors and a fixed-exit double-crystal monochromator. These optical elements can be removed completely for an experiment involving white X-rays. This beamline has two experimental hutches. One is a white X-ray hutch dedicated to high-pressure and dispersive XAFS experiments with white X-rays. The other is a monochromatic X-ray hutch dedicated to XAFS, X-ray diffraction measurements, and X-ray irradiation experiments. BL14B1 can be a one-stop platform for the development of novel functional materials by the complementary use of white and monochromatized X-rays.

2. High-pressure and high-temperature experiments

High-pressure and high-temperature syntheses have been performed at the white X-ray hutch. *In situ* synchrotron radiation X-ray diffraction measurements can detect structural changes of a sample under high pressure and temperature. Consequently, the synthetic conditions of novel materials can be easily searched.

Currently, research focuses on synthesizing and characterizing novel hydrides. In FY2022, rotational mechanisms of complex ions in Li_5MoH_{11} and Li_6NbH_{11} were investigated by measuring quasielastic neutron scattering, where the synthetic conditions of the target materials were determined by the in situ synchrotron radiation X-ray diffraction technique [1].

The formation of a novel iron-based alloy hydride with an hcp structure was confirmed by *in situ* synchrotron radiation X-ray diffraction measurement at 9 GPa. The formed hydride evolved hydrogen at room temperature during decompression. The dehydrogenation reaction caused unique microstructural morphologies [2].

$LaNi_5$ alloy is a typical hydrogen storage alloy and can absorb hydrogen up to $LaNi_5H_6$ at around ambient pressure. Sato et al. revealed that $LaNi_5H_6$ can be hydrogenated further to form $LaNi_5H_{\sim 9}$ above 6 GPa [3].

3. Stress

A stress measuring device with a two-dimensional (2D) CdTe pixel detector and solid-state detector is installed at the white X-ray hutch. The feature of this stress measurement is that stress distribution inside a material can be measured by using high-energy X-rays. In particular, the double-exposure method (DEM) using a 2D detector is effective for materials with coarse grains. In FY2022, the DEM using high-energy synchrotron radiation monochromatic X-rays was carried out for strain measurements of a small-bore butt-welded pipe made of austenitic stainless steel with 14 mm thickness [4].

By using the DEM, maps of 2D strain distributions in the axial and radial directions of the root-welded part of the plate cut from the butt-welded pipe were successfully obtained. On the other hand, that in the hoop direction was obtained using neutron diffraction at RESA in JRR-3, because of the insufficient X-ray penetration depth for this sample. Detailed three-axis stress maps of the root-welded part of the butt-welded pipe were obtained by combining the synchrotron and neutron data.

4. XAFS

XAFS observation using an energy-dispersive optical system was carried out at the white X-ray hutch, as well as a conventional optical system at the monochromatic X-ray hutch [5–10]. Various XAFS measurements such as those involving high-speed chemical reactions and low-concentration additives can be performed.

Several in situ observation devices have been prepared both in the energy-dispersive optics system and the conventional optics system. Remote control apparatus such as gas flow controllers, switching valves, potentiostats, and injectors are always available. Some experiments using laser systems are also carried out. Time-resolved measurements are performed for gas conversion reactions, electrode reactions, ligand substitution reactions, and so forth. In FY2022, CO_2 hydrogenation to methanol by Cu/ZnO catalysts was observed by time-resolved XAFS measurement at Cu and Zn K-edges. The precise mechanism of the catalytic reaction was studied by the simultaneous observation of Cu and Zn K-edges with dispersive optics.

In the conventional optical system, low-concentration XAFS measurements are performed using a 36-element solid-state detector. Local structure measurements of Cs-including clay minerals at Cs K-edge XAFS were carried out from the viewpoints of stable storage and volume reduction of radioactive wastes. A correlation between the layered structure of weathered biotite clay and the Cs sorption site was detected by the observation of the weathering-controlled samples at low temperatures. We are continuing research to reveal the relationship between the structure of soil and the sorption state of cesium ions, thereby leading to mobility evaluation and the selective collection of radioactive cesium ions.

5. X-ray irradiation effects on a tumor

The X-ray irradiation effects on a tumor were investigated for developing Auger therapy. Tumor spheroids containing I-Hoechst were irradiated with synchrotron radiation monochromatic X-rays to generate Auger electrons from I atoms that were placed near DNAs. The irradiation experiments were carried out at the monochromatic X-ray hutch. In FY2022, the effects of new drugs were investigated. In addition, a cell culture area was established in the sample preparation room at BL14B1. We have already succeeded in culturing Chinese Hamster Ovary (CHO) cells and Human Ovarian Carcinoma (OVCAR-8). Cultured cells and spheroids are used for irradiation experiments at BL14B1.

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