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 is 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.

In FY2023, we developed a new high-pressure cell design that enables us to measure the hydrogenation reactions of two or three samples simultaneously. In combination with an automatic measurement system, the hydrogenation pressure-temperature conditions of materials can be determined quickly. Some novel hydrides have already been synthesized using this technique.

Some hydrogenation reactions below 1 GPa have been investigated at BL14B1, whereas such reactions above several GPa have been intensively investigated. This is because the results of hydrogenation experiments in such a relatively low-pressure region can be compared with those obtained through gaseous hydrogen experiments conducted below 0.01 GPa. Charbonnier et al. investigated the hydrogenation reaction of C14 Laves alloy at around 0.1 GPa [1].

Other synthesis studies of hydrogen-related materials have been carried out. A formation mechanism of perovskite oxyhydrides has been investigated using the *in situ* observation system [2]. Hydrogenation reactions of Fe–Mo alloy and changes of microstructures caused by the hydrogenation reactions were also investigated [3].

3. Stress

Synchrotron white X-rays were used to carry out *in situ* Laue diffraction measurements during heating of a fine-grained magnesium alloy after rolling. The experiment revealed the mechanism of abnormal grain growth of magnesium alloy [4].

Hojo et al. investigated the stress and plastic strain distribution and the partitioning behavior of ferrite, retained austenite in medium manganese, and the transformation-induced plasticity-aided bainitic ferrite steels. They analyzed the Lüders elongation and martensitic transformation of retained austenite during work hardening behavior [5].

Suzuki et al. complementally used synchrotron radiation X-rays and neutrons to measure residual stresses in welds. Detailed stress maps of the root part of the butt-welded pipe were obtained. They named this analysis method the quantum beam hybrid stress analysis [6].

4. XAFS

XAFS observation using an energy-dispersive optical system was carried out at the white X-ray hutch, as well as using a conventional optical system at the monochromatic X-ray hutch [7–11]. Various XAFS measurements, including those of 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 reactions such as gas conversion reactions, electrode reactions, and ligand substitution reactions. In FY2023, CO_2 hydrogenation to methanol by Cu/ZnO catalysts was observed by time-resolved XAFS measurement at Cu and Zn K-edges under a 9 bar gas flow condition. The precise mechanism of the catalytic reaction under a high-pressure atmosphere was studied by the simultaneous observation of Cu and Zn K-edges using dispersive optics.

In the conventional optical system, low-concentration XAFS measurements are performed using a 36-element solid-state detector. Local structural measurements of Cs-containing clay minerals at the 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 observing weathering-controlled samples at 20 K. It was found that the existence of a layered structure that is partially broken is important for the stable adsorption of cesium ions. We are continuing research to reveal the relationship between the structure of soil and the sorption state of cesium ions, which will lead to mobility evaluation and the selective collection of radioactive cesium ions.

5. X-ray irradiation effects on a tumor

Biological irradiation experiments using both white and monochromatic X-rays were started in FY2023. For the experiments, dose assessments were performed at BL14B1. The effective energy of white X-rays was assessed to be 120 keV, and their average dose rate was determined to be 170 ± 10 Gy/s using an L-alanine dosimeter. We have also investigated dose rates of monochromatic X-rays using an optical stimulated luminescence detector. The average dose rate of monochromatic X-rays with 33.2 keV was evaluated to be 0.099 ± 0.006 Gy/s.

SAITOH Hiroyuki[*1], SHIRO Ayumi[*1], SHOBU Takahisa[*2], and MATSUMURA Daiju[*3]

[*1]Hydrogen Materials Research Group, Synchrotron Radiation Research Center, National Institutes for Quantum Science and Technology (QST)

[*2]Hierarchical Structure Research Group, Materials Sciences Research Center, Japan

Atomic Energy Agency
*3Advanced Energy Materials Research Group, Materials Sciences Research Center, Japan Atomic Energy Agency

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