

KOTOBUKI-1 apparatus for cryogenic coherent X-ray diffraction imaging at SPring-8 and SACLA

Masayoshi Nakasako^{1,2}, Yuki Takayama^{1,2}, Tomotaka Oroguchi^{1,2},
Yuki Sekiguchi^{1,2}, Amane Kobayashi^{1,2}, Keiya Shirahama¹,
Masaki Yamamoto², Takaaki Hikima², Koji Yonekura², Saori Maki-Yonekura²,
Yoshiki Kohmura², Yuichi Inubushi²,
Yukio Takahashi^{2,3}, Akihiro Suzuki^{2,3},
Sachihiro Matsunaga⁴, Yayoi Inui⁴,
Kensuke Tono⁵, Takashi Kameshima⁵, Yasumasa Joti⁵,
Takahiko Hoshi⁶

¹*Department of physics, Faculty of Science and Technology, Keio University, 3-14-1 Hiyoshi, Kohoku-ku, Yokohama 223-8522, Japan.* ²*RIKEN SPring-8 Center, RIKEN Harima Institute, 1-1-1 Kouto, Sayo, Hyogo 679-5148, Japan.* ³*Department of Precision Science and Technology, Graduate School of Engineering, Osaka University, 2-1 Yamadaoka, Suita, Osaka 565-0871, Japan.* ⁴*Department of Applied Biological Science Faculty of Science and Technology, Tokyo University of Science, 2641 Yamazaki, Noda, Chiba 278-8510, Japan.* ⁵*Japan Synchrotron Radiation Research Institute, 1-1-1 Kouto, Sayo, Hyogo 679-5198, Japan.* ⁶*Kohzu Precision Co., Ltd., 2-6-15 Kurigi, Aso-ku, Kawasaki, Kanagawa 215-8521, Japan.*

We have developed an experimental apparatus named KOTOBUKI-1 for use in coherent X-ray diffraction imaging experiments of frozen-hydrated non-crystalline particles at cryogenic temperature. We here use a cryogenic pot cooled by the evaporation cooling effect by liquid nitrogen as a cryogenic specimen stage with small positional fluctuation for a long exposure time of more than several minutes. To bring specimens stored in liquid nitrogen to the specimen stage in vacuum, a loading device and miscellaneous devices are developed. Biological specimens are prepared in frozen-hydrated state using a humidity controlled specimen preparation chamber [1]. The apparatus allows diffraction data collection for frozen-hydrated specimens at 66 K with a positional fluctuation of less than 0.4 μm , and provide an experimental environment to easily exchange specimens from liquid nitrogen storage to the specimen stage. The apparatus was used in diffraction data collection of non-crystalline particles with dimensions of micron from material and biological sciences, such as metal colloid particles and chloroplast, at BL29XU of SPring-8. Very recently, the apparatus has been utilized for single-shot diffraction data collection of non-crystalline particles with dimensions of sub-micron using X-ray free electron laser at BL3 of SACLA. A program suite SHITENNO has been developed for automatic data processing and phase retrieval calculations [2] of collected diffraction data.

[1] Y. Takayama, and M. Nakasako, *Rev. Sci. Instrum.* **83**, 054301 (2012).

[2] T. Oroguchi, and M. Nakasako, *Phys. Rev. E* **87**, 022712 (2013).