Improvements of the soft X-ray grating monochromator at BL27SU.

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A new cooling system for the spherical mirrors and the gratings of the varied-line-spacing plane grating monochromator (VLS-PGM) on the BL27SU is designed and installed. In this project, the performance test has been done.

The original design of the monochromator is described in previous report [1]. The first commissioning of the VLS-PGM has already been done and we confirmed the resolving power of >10000. [2] However, the strong photon beam from the Figure-8 undulator causes the serious heat load problem that shift the dispersed photon energy during the experiments. For example, at the 530 eV of photon energy, the temperature rise of 1℃/hour was observed in the spherical mirror and grating and the energy shift of 20 meV/hour was observed. This energy shift was the almost same scale of the photon energy resolution and it was a serious problem for the various high-resolution experiments.

The requirements for the cooling system of the soft X-ray monochromator are as follows: (1) high heat conduction (2) to keep the smooth movements for scanning and adjustment of the optics (3) the quality of the material fits the ultra high vaccum system. In order to satisfy these conditions, we have designed a cooling system using liquid metal bath.

The cooling system of spherical mirror constructs by two Al cooling plate and a water-cooled liquid metal bath. The heat in optics is removed by two Al cooling plate with the two long side of each optics. In order to improve the thermal contact between the mirror and the cooling plate, thin In seats are installed between them. The Al cooling plates are partly soaked into the liquid metal bath. The bath is filled with a mixed liquid metal of 84 wt. % gallium and 16 wt. % indium. The mixed gallium and indium is used in previous system to make good thermal contact, and can be used in ultra high vacuum system. [3] The liquid metal bath is cooled by cooling water circulator and the temperature of bath is kept at 22 ℃ during the experiments.

In the case of grating, the cooling system is constructed by two Al cooling plate with heat pipe and liquid metal bath. A part of heat pipe is soaked into the liquid metal bath. Others are the same system as the spherical mirror.

In the performance test of new cooling system, it was observed that the temperature rise at the 530 eV of photon energy is reduced by only 0.1 ℃/hour, Moreover, from the measurement of high resolution photoelectron spectrum, it was also observed that the energy shift is reduced 10 meV or less. These results mean the successful cooling of the new cooling system.

Reference

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Irradiation effects of focused soft-X-rays with electrical materials

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Recently, high-flux soft X-rays from undulator can be available at the third generation facilities such as SPring-8. However, the changes or reactions of thin films owing to the effects of such strong light are not well known. The etching of thin films by irradiation with soft X-rays has been reported. PTFE is strongly etched[1], but the evaporation rate is slow especially in the case of inorganic electrical materials such as SiO_2, PZT and high-k dielectrics. So, in order to enhance the evaporation, microbeam of soft X-ray undulator light using an elliptically bent mirror is irradiated inorganic electrical materials. We described in the previous report[2], that the soft X-ray microbeam could be produced by using the elliptically bent mirror. The beam size was about 20 μm, and the demagnification of the mirror is a few tens. Therefore, we can expect an increase of the photon flux density.

Figure 1 shows the surface profile observed by digital microscope (KEYENCE, VK-8550). The sample is quartz plate of 0.5 mm thickness after the irradiation with focused soft X-ray undulator light which is not monochromated. The irradiations have been carried out at room temperature in the vacuum chamber of 1×10^{-5} Pa for 60 min. Undulator gap width is 80 mm (1899 eV_{1st}) which can be excited Si 1s core level. Photo-induced etching is clearly observed. The width of groove which is the irradiated region is about 30 μm, and this value is close to the microbeam size. Figure 2 shows the surface profile of the sapphire plate. Gap width is 57 mm (720 eV_{1st}). In our previous work, evaporation has not been observed when unfocused undulator light was irradiated with a sapphire plate. This results that the high-flux beam can enhance the photo assisted evaporation and makes it possible to process the electrical materials.

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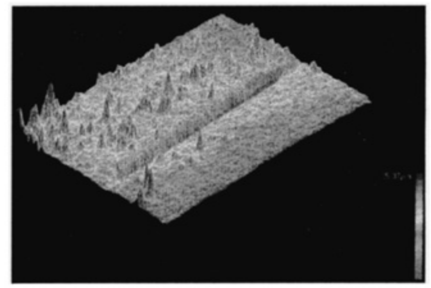

Figure 1: Surface profile of the silica glass plate after SR-irradiation.

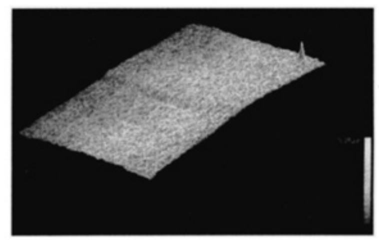

Figure 2: Surface profile of the sapphire plate after SR-irradiation.