11B/2006G217

Absolute measurement for intensity of soft X-ray using cryogenic radiometer

Masahiro Kato, Isao H. Suzuki, Yuichiro Morishita, Tadahiro Kurosawa, Norio Saito*
National Metrology Institute o Japan, AIST, 1-1-1 Umezono Tsukuba, Ibaraki 305-0801, Japan

Introduction

The absolute intensities of the soft x-ray have been measured using a multi-electrode ion chamber with a relative standard uncertainty of about 2 % in National Metrology Institute of Japan/AIST while using a cryogenic radiometer, which is developed by Rubus et al. [1], the intensity can be measured with a relative standard uncertainty of about 0.2 %. In this study, we have developed a cryogenic radiometer for the absolute intensity measurement of soft x-ray to improve the performance of the soft x-ray intensity measurement.

Experiment

Apparatus

The experiment was performed at the beamline 11B at the Photon Factory. Synchrotron radiation was monochromatized by a double crystal monochromator [2]. The monochromatized synchrotron radiation with the resolution power of 1000 was used in the energy region from 1.9 keV through 3.9 keV. The experimental setup and performance of the cryogenic radiometer used in the present study were described in detail elsewhere [3-5]. The radiometer was cooled with liquid helium. The cavity absorber, which was made of copper, is able to absorb the soft x-ray completely in the present energy range.

Procedure for measurement of the absolute soft x-ray intensity

The soft x-ray intensity with the radiant power P(W) is given by

$$P = \Delta T/s, \qquad (1)$$

where ΔT (K) denotes the temperature rise in the cavity absorber, and s (K/W) indicates the thermal responsivity of the cavity absorber. The stabilized temperature of the background at the cavity was about 5.915 K with a fluctuation less than 0.05 % for a typical measurement period of 10 mim. Figure 1 indicates a typical example of the cavity temperature as a function of time lapse at the photon energy of 3.0 keV. The monochromatized x-ray focuses onto the cavity of the radiometer when the gate valves in front of the radiometer are open. The temperature of the cavity rose by the amount of 41.56 mK in about 1 minute and then became steady, exhibiting a fluctuation smaller than 0.1 mK. In order to obtain the thermal responsivity of the cavity, s, the temperature rise was measured as a function of input heater power. s was determined with the uncertainty of 0.1 % (coverage factor of $k = 2$).

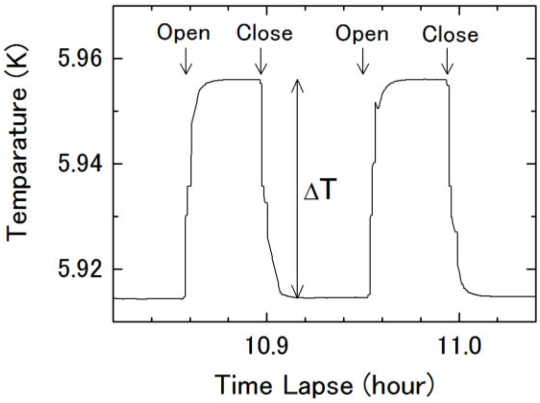

Fig. 1. An example of the cavity temperature as a function of time lapse at the photon energy of 3.0 keV. The arrows indicate “open” and “close” of the gate valve.

Results

The result and the uncertainty budget of the measurement at the photon energy of 3.0 keV are listed in Table 1. The radiant power P can be measured using the cryogenic radiometer with the relative standard uncertainty of 0.16 % at 3.0 keV. The uncertainty of the measurement of the radiant power in the energy range of 1.9 keV – 3.9 keV is less than 0.2 % (k = 1) in the present study.

Table 1: Result and uncertainty budget of the measurement of soft x-ray at the energy of 3.0 keV.

	Value	Uncertainty (k=1)
ΔT	41.56 mK	0.15 %
s	5.490 mK/μW	0.05 %
P	7.57μW	0.16 %

References

[1] H. Rabus et al., Applied Optics 36, 5421 (1997).
[2] Y. Kitajima, J. Electron Spectrosc. Relat. Phenom. 80, 405 (1996).
[3] Y. Morishita et al., J. Electron Spectrosc. Relat. Phenom. 144, 1071 (2005).
[4] M. Kato et al., AIP Conference Proceeding 879, 1129 (2007).
[5] M. Kato et al., Rad. Chem. Phys. submitted.

*norio.saito@aist.go.jp