Instrumentation and Technique

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Observation of non-linear effect in soft X-ray region with GaAs thin film

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Introduction

The non-linear (NL) effect in the x-ray region is a promising study to explore a new science utilizing the intense x-ray such as the FEL. Some attempts in observing the NL effect with the SR has been performed in the hard x-ray region [1]. However, the NL effects in the soft x-ray region have not been observed, and it is important to establish the technique to observe the NL effect for future earnest experiments. For this purpose, we have developed a new apparatus in observing the second-harmonic generation in the soft x-ray region.

Result and Discussion

The experiment was performed at an undulator beamline BL-16B. A brief layout of the instrument in the vacuum chamber is shown in Fig. 1. The monochromatized beam is incident to a plane mirror. The half of the beam is reflected by the plane mirror and the other half goes through the mirror. The divided beams are reflected by two toroidal mirrors and are focused on a GaAs thin film, respectively. The beamsize on the GaAs film was about 200 μm. The GaAs film was prepared by the vacuum-evaporating method. The material of the substrate of the film was polycarbonate and the thickness of the GaAs film was about 1000 Å.

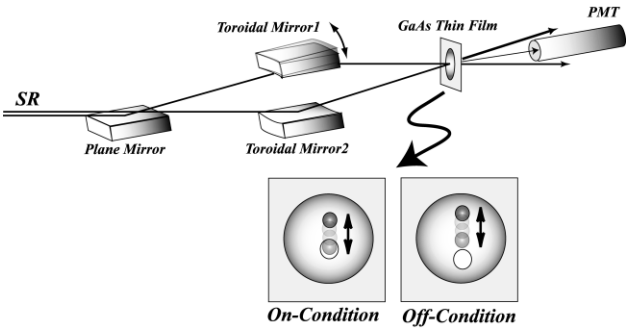

Figure 1: Layout of the optical system and the beam position on the GaAs film.

We can modulate the focal position of one beam by vibrating the upper toroidal mirror with a piezo actuator. The second-harmonic generation occurs only when the two beams have an overlap on the GaAs film, and the beam corresponding to the second harmonic, which is measured by a PMT, proceeds in the direction of the sum of two direction vectors of the incident beams. The output current of the PMT is proportional to the magnitude of the signal due to the NL effect. The probability of the second-harmonic generation is expected to be extremely small. Therefore, we have modulated the position of one beam reflected by the upper toroidal mirror with about 1 Hz, and measured the PMT signal with a lock-in amplifier (LA). We have performed the experiment in two conditions as shown in Fig. 1. At first, we adjusted the beam position on the GaAs film so that two beams have an overlap during the modulation (*on-condition*). Next, we changed the position of the beams so that two beams have no overlap during the modulation (*off-condition*). Since the NL effect will occur only in "*on-condition*", the output of the LA is expected to change only in this condition as the photon energy changes.

The right figure in Fig. 2 shows the absorption spectrum of the GaAs film near the absorption edge of As. We determined the photon energies for the measurement of the NL effect as indicated in the figure. The left figure in Fig. 2 show output of the LA for the different photon energies. The output of the LA in "*off-condition*" has no photon-energy dependence, and this shows that the NL effect does not occur in this condition. The output of the LA in "*on-condition*", on the other hand, has clear photon-energy dependence. This shows that the second harmonic was generated due to the x-ray absorption by the GaAs film.

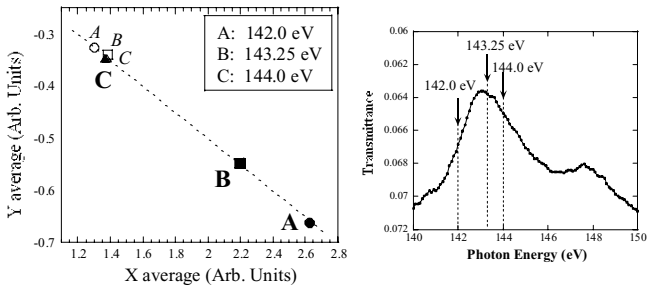

Figure 2: Output of the LA for the different photon energies near the As absorption edge (left). The closed (open) marks indicate the results measured in "*on-condition* (*off-condition*)". The right figure shows the absorption spectrum of GaAs near the As absorption edge.

References

[1] Y. Yoda et al., J. Synchrotron Rad. 5, 967 (1998).

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