16B/2004G213

Observation of the second harmonic generation in the soft x-ray region

Yasuhiro TAKAYAMA*[1], Koutatsu SHIBASAKI[1], Naoya SASAKI[1], Yuji NAKAYAMA[1], Keisuke NISHIHATA[1], Yuichi YONEDA[1], Tetsuo YOSHIDA[1], Satoshi NAKAMURA[1], Hiroyoshi ISHII[1], Tsuneaki MIYAHARA[1], Jun OKABAYASHI[2], Ken KANAI[2], Masaharu OSHIMA[2] and Shigeru YAMAMOTO[3]

[1]Tokyo Metropolitan Univ., Hachioji-shi, Tokyo 192-0397, Japan
[2]The Univ. of Tokyo, Bunkyo-ku, Tokyo 113-8656, Japan
[3]KEK-PF, Tsukuba, Ibaraki 305-0801, Japan

Introduction

Recent developments on the technology of the high-brilliant-light source give us a chance to perform the experiments of new types. The nonlinear phenomenon only with the synchrotron radiation (SR) is one of the most interesting topics, but has not been observed up to now. In order to establish the experimental technique of the nonlinear optics, we have constructed a novel instrument for detecting the second harmonic generation (SHG) in the soft x-ray region. The SHG occurs only in a crystal without the space-inversion symmetry [1], and we have selected the GaAs film as a sample and performed the SHG measurement around the As 3*p*-absorption edge.

Experimental

The GaAs thin film was prepared by the vacuum evaporation on the polycarbonate substrate, where the thicknesses of the GaAs film and the substrate are 2000 Å and 5500 Å, respectively. Fig. 1 shows a brief layout of the optical system for the SHG measurement. The monochromatized SR comes from the left side, and the SR is split into two beams by a plane mirror. Each beam is focused on the GaAs thin film by a toroidal mirror. The position of the beam from the upper toroidal mirror can be modulated by a piezo actuator. The motion of the piezo actuator is controlled by a function generator which generates the sine wave with the frequency of about 1 Hz.

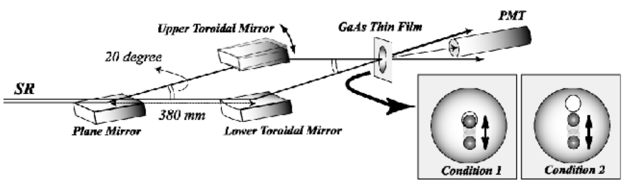

Figure 1: Optical system for the SHG measurement.

The second harmonic is generated only when the two beams on the film has an overlap each other. The signal of the SHG is detected by a photomultiplier tube (PMT). We have performed the experiments on the two conditions as shown in Fig. 1, where the SHG signal is expected to appear only on the condition 1. The output current from the PMT is analyzed by a digital lock-in amplifier (LA). X and Y denote the sine and cosine components of the outputs of the LA, respectively. In our experimental setup, X and Y should be positive and zero, respectively, if the SHG signal is detected. By subtracting the X and Y outputs measured on the condition 2 from those on the condition 1, the signal of the SHG can be obtained.

Results and Discussion

Fig. 2 shows the transmittance spectrum of the GaAs film and the outputs of the LA. The measurement of the SHG was performed at the photon energies indicated in the transmittance spectrum. X_1, Y_1 and X_2, Y_2 are outputs of the LA on the conditions 1 and 2, respectively. The differences of these values of ΔX and ΔY correspond to the SHG signal. ΔX at the photon energies of 140 eV and 141.5 eV is positive, and this indicates that the SHG signal was observed around the photon energies of the As 3*p* pre-threshold region. ΔY also depends on the photon energy, and this result is not consistent with the expected output of the SHG signal. The reason of the discrepancy might come from the incomplete adjustment of the beam position from the lower toroidal mirror. In this case, the timing of the pulse current from the PMT due to the SHG signal changes and, consequently, the Y component also takes the non-zero value. For the confirmation of the detection of the SHG signal, more experiments with high precision and with different samples are required.

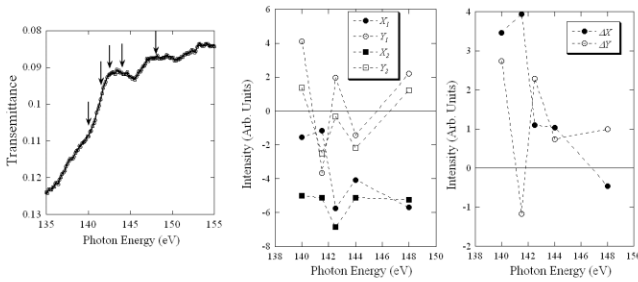

Figure 2: Transmittance spectrum of the GaAs film (left) and the outputs of the LA (center and right).

References

[1] Y. R. Shen, *The Principles of nonlinear Optics*, New York: John Willey & Sons, Inc., 76 (1984)

* takayama@phys.metro-u.ac.jp