Development of a High-Count-Rate APD Detector System Having Energy Resolution with a Flash ADC for the White X-ray Magnetic Diffraction Experiment

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Introduction

The white X-ray magnetic diffraction (WXMD) is a unique tool which enables us to measure spin-moment component and orbital-moment component of the magnetic form factors of ferromagnets separately[1]. This method utilizes white X-rays of elliptically polarized synchrotron radiation from a bending magnet emitting out of the electron orbit plane of a storage ring. The advantage of the white X-ray method over a monochromatic X-ray method is that magnetic form factors at plural reciprocal lattice points are measured simultaneously in a measurement by using a detector having energy resolution. To date, a solid-state detector (SSD) of Ge or Si has been mostly used because of its better energy resolution than other detectors such as a proportional counter (PC) or a scintillation counter (SC).

A disadvantage of the SSD over the PC or SC is low count-rate capability. For example, a pure-Ge SSD is usually operated at count rate less than 10^4 counts/sec. Due to this low count-rate capability, the white X-ray magnetic diffraction needs long measurement time for obtaining good statistical accuracy. Recently an APD (Avalanche Photo Diode) detector was developed by one of the present authors (S. K.) which has a very high count-rate capability of 10^7-10^8 counts/sec[2]. The disadvantage of the APD is low energy resolution, and there has been no such ADC (Analogue to Digital Converter) as is capable of dealing with fast pulses of high count rate of 10^7-10^8 counts/sec.

In the present study we developed an APD detector system which has reasonable energy resolution and is capable of dealing with fast pulses by using a newly developed fast ADC module (flash ADC).

Experimental

The WXMD measurement was made at the BL3C$_3$ where a diffractometer optimized to this experiment is installed. We developed a program which controls the detector system through the CAMAC using a programming language, Labview.

The specimen was $SmFe_2$ crystal. The reflection plane was (1 1 0), and the scattering angle was 90 degree. The magnetic field of 10kOe was applied along the incident X-ray beam. We measured the change in the diffraction intensity of the reciprocal lattice points of *h h* 0 (*h*=4,6,8) caused by reversing the magnetic field direction every 120 sec (so called the flipping ratio). The APD element was cooled down to –20 ^{o}C to obtain better energy resolution.

Result and Discussion

The observed diffraction intensity of a magnetic-field direction, I_P, is plotted in Fig. 1 (a) as a function of the X-ray energy. The measurement time was 840 sec. The change in the diffraction intensity by reversing the magnetic-field direction, $\Delta I=I_P-I_N$ (I_N is the diffraction intensity for the reversed magnetic-field direction), is potted in Fig.1 (b). The total measurement time was 1680 sec. As the thickness of the APD element is only 0.13mm, so the measured diffraction intensity of higher energy for 660 and 880 is small because most of the X-rays transmit the element. When we concentrate on the 440 diffraction peak, the count rate amounts to $5X10^5$ counts/sec and the observed flipping ratio R ($=\Delta I/(I_P-I_N)$) is 0.266 ± 0.004 % for the measurement time of 30min. The statistical error is very small even for 30min measurement time. From Fig.1 (a) the energy resolution is estimated as $\Delta E/E=0.2$ which is comparable to that of a proportional counter. We might need better energy resolution for separating subsequent peaks in the profile. This detector system will help us to shorten measurement time and to improve accuracy of the measurements.

In conclusion, a fast APD detector system having reasonable energy resolution was developed and applied successfully to the WXMD measurement of diffraction intensity of $5X10^5$ counts/sec. We thank Dr. H. Miyagawa and Prof. S. Nanao for the loan of the single crystal of $SmFe_2$.

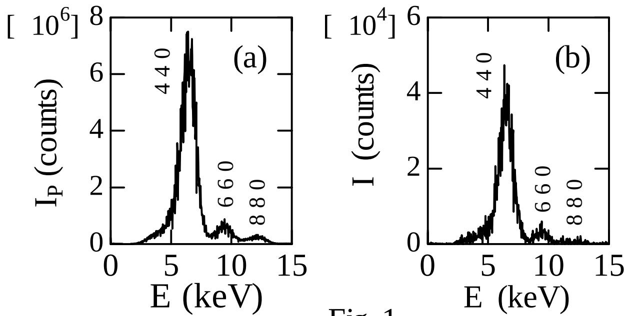

Fig. 1

References

[1] D. Laundy et al., J. Phys. :Condens. Matter **3** 369 (1991).
[2] S.Kishimoto et al., Rev. Sci. Instrum. 69 384(1998).

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