Development of variable scattering plane method in X-ray magnetic diffraction VII

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A dynamic range of a detector as well as the polarization analysis has an influence on difficulty of Non-Resonant X-ray Magnetic Scattering (NRXMS) experiments. A NaI scintillation detector, which is widely used, has a maximum counting rate of 30 kcps limited by the damping time constant of NaI:Tl scintillator. However, its practical bandwidth narrows down to about 20 dB since rather low counting rate is unuseful for instantaneous data collection with sufficient statistical precision. Thus, the NaI scintillation detector is inefficient for NRXMS experiments which need a dynamic range of about 140 dB. The purpose of this work is to improve the bandwidth of a detector with YAP:Ce scintillator.

The SR beam from the undulator at the BL46XU was used with tuning an X-ray energy on 16 keV. The incident photon number was regulated with the number of molybdenum foils of 50 μm. Output pulses from the photomultiplier were directly fed into a pulse height analyzer so as to exploit the short damping time constant (27 nsec) to the limit. Figure 1 shows pulse height distribution obtained with using BC-630 and 6282A optical compound. It was found that their distribution center coincide with each other and there is no deference of transmittance for the wavelength of 350 nm. Fig. 2 shows counting rate as a function of an incident photon number. Counting loss is no more than 4.8 % for incident photons of 1.85 Mcps.

In this study, we have succeeded in inproving a maximum counting rate and achieving the practical bandwidth of 60 dB.

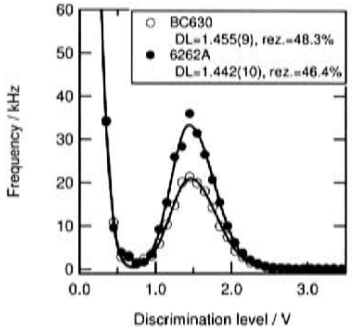

Fig. 1. Pulse height distribution for X-rays of 16 keV. Open and closed circle represent the results obtained with using BC-630 and 6282A optical compound, respectively.

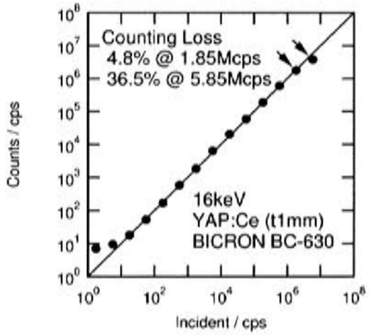

Fig. 2. Counting rate vs Incident photon number. Achieved maximum counting rate is two orders of magnitude lager than that of NaI:Tl. Counting loss is mainly caused by deficiency in supply current for the photomultiplier.

Structural Analysis of Passive Film on Iron Surface by Grazing Incidence X-Ray Scattering Method

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The origin of the high corrosion resistance of a stainless steel is attributed to very thin passive film on the surface stabilized by specific alloying elements, Cr, Ni, etc. The mechanism of the stabilization has not yet been elucidated because the structure of the passive film is not unclear. The clarification of the structure needs the technique of the X-ray scattering measurement on the thin oxide films of a few nm thickness. We tried to measure the X-ray scattering from the oxide films on the stainless steels by grazing incidence X-ray scattering (GIXS).

We prepared two samples of SUS316L substrates with specular surfaces. Their surfaces were polished as smooth as mirrors. One of them was oxidized in the air (Sample 1), and the other was oxidized in the high temperature water (Sample 2). The thickness of the oxide films on their surface of Sample 1 was estimated at about 2 nm, and that of Sample 2 was estimated at about 50 nm. In order to suppress the penetration depth of the X-ray, the glancing angle of the incident X-ray (E = 12 KeV) to the surface were fixed at about 0.1 degree, which is below the critical angle of total reflection (about 0.5 degree).

Figure 1 shows the profiles of the X-ray scattering from the surface of the samples. As shown in the data of the sample 1, we successfully detected the broad peaks of the scattering from the passive film except for the diffraction peaks of the substrate. In the data of the sample 2, only the diffraction from the oxide film with the spinel structure is shown and the signal from the substrate is completely suppressed. As shown by these data, we succeeded to observe the X-ray scattering from the oxide thin films on the stainless steels by GIXS.

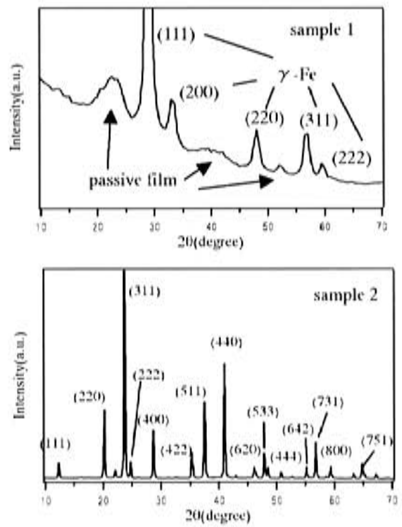

Fig.1 The X-ray scattering profiles from the oxide films on the stainless steels.