Crystallography

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Magnetic ordering in $BaTiCoFe_{10}O_{19}$ observed by resonant x-ray magnetic scattering

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Introduction

Resonant x-ray magnetic scattering (RXMS) has attracted much interest as a useful tool to determine the magnetic structures associated with specific electronic states such as 3*d*-4*p* interactions. The RXMS experiment in ferromagnetic Ni was first made at the Ni *K* edge [1]. Large resonant exchange scattering was predicted in *L* and M absorption edges to dominate the magnetic scattering [2]. The Bragg intensity was estimated with the resonant enhancement between charge and magnetic scatterings at the *L* edge of the rare-earth systems [3]. Various resonant experiments have been carried out for the x-ray energies near the M_{IV} edges of actinides and near the L_{III} edges of rare-earth and transition-metal compounds [4]. There are not so many reports on the *K* edge of 3*d* transition metal because of relatively weak enhanced intensity. It is now known that magnetic resonance arises from the spin-orbit coupling at the *K* edge through the process of either strongly polarized 3*d* band or interatomic exchange between 4*p* and 3*d* sates [5,6].

In this study, the magnetic structure of M-type $BaTiCoFe_{10}O_{19}$ has been examined to confirm the potential ability of RXMS in the relatively complicated system.

Experimental

Single crystals of $BaCoTiFe_{10}O_{19}$ were synthesized by a flux method. Diffraction experiments were carried out at the Fe *K* absorption edge at BL-3A and BL-10A. The horizontally polarized white x-rays were monochromatized by the Si(111) double-crystal monochromator.

A four-circle geometry at the BL-3A was used for the RXMS study at 100 K. Low-temperature experiments were performed with the Oxford Cryostream Cooler, where cold and dry nitrogen gas is directly blown onto the crystal.

Results and discussion

X-ray diffraction experiments for $BaCoTiFe_{10}O_{19}$ were made at a wavelength of $\lambda = 1.7406$ Å ($E = 7122.8$ eV) at the Fe *K* edge, based on the characteristic XMCD signals for the crystals. A magnetic reflection appears at 100 K (Fig. 1), which does not obey the extinction rules of the $P6_3/mmc$ symmetry and is noted 0 0 8+(2/3). Although the satellite reflection associates with the diffuse intensity, the sharpness of peak is characteristic for a long-range magnetic order. The appearance of the peak coincides with the result by the neutron diffraction for $BaCo_{0.8}Ti_{0.8}Fe_{10.4}O_{19}$, which was interpreted in terms of a magnetic helix propagated along the hexagonal *c* axis [7]. Thus, it is conclusive that the Fe *K* edge can excite resonantly but indirectly the 3*d* states and the magnetic resonant enhancement is sufficiently large to study the magnetic order of Fe compounds.

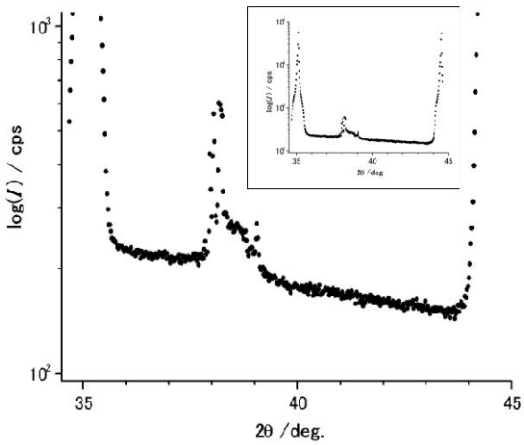

Fig.1, Scans between 008 and 0 0 10 reflections of $BaCoTiFe_{10}O_{19}$. Beside the fundamental reflections, 0 0 8+(2/3) reflection is observed at $T = 100$ K. The inset shows the same measurements on a full scale. The satellite reflection disappeared at $T = 200$ K.

References

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