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Resonant X-ray scattering from hematite, Fe_2O_3, below the Morin temperature

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Introduction

Hematite, α-Fe_2O_3, has a corundum structure with antiferromagnetic moments perpendicular to rhombohedral [111] axis at room temperature. At the Morin temperature (T_M = 250 K) their directions change parallel to the [111]. Anisotropic resonant scattering from hematite was first observed by Finkelstein et al.[1] and they concluded that the observed azimuthal angle dependence is attributed to only electronic quadrupole transitions.

We measured before the energy spectra of the 111 and 333 forbidden reflections intensities near the Fe K-absorption edge at room temperature. Both spectra showed one peak in the pre-edge region and small non-resonant intensity. The azimuth dependence of the 111 and 333 reflections measured at the non-resonant energy showed twofold symmetry. At the resonant energy, on the other hand, the 111 azimuth dependence showed threefold pattern and that of the 333 reflection showed complicated pattern.[2,3] In this report, we have investigated the reflections below the Morin temperature in order to explain the magnetic scattering contribution.

Experimental Results

The experiment was carried out with four-circle diffractometers at BL4C, where the incident beam was σ-polarized. The integrated intensities were measured for the 111 and 333 forbidden reflections at different temperature, X-ray energies or azimuthal angles around the scattering vector.

Figure 1 shows the temperature dependence of the 111 forbidden reflection intensity at non-resonant energy. The intensity is decreasing from the 250 K and almost vanishes below the 200 K. This result indicates that the magnetic moments do not contribute to the reflection below the Morin temperature because their directions change. This property can be explained by non-resonant magnetic scattering due to the antiferromagnetic structure.

Figure 2 shows the azimuthal angle dependence of the 333 forbidden reflection at 150 K and the resonant peak energy. This result shows obviously threefold symmetry in contrast to the intricate pattern at room temperature.

The observed 333 azimuth dependence (dots) in Fig. 2 is in good agreement with the fitting curve based on the electric dipole-quadrupole and quadrupole-quadrupole scattering (solid line). The threefold pattern of the 111 azimuth dependence does not change below the Morin temperature and is also explained by these electric transitions. These results indicate that the 333 reflection at low temperature and the 111 reflection are caused by only electric multipole transition process.

Moreover the resonant 333 reflection intensity at room temperature is much larger than that of the non-resonant one. From these results we conclude that the complicated azimuth dependence of the resonant 333 reflection is affected by spin-dependent resonant magnetic scattering.

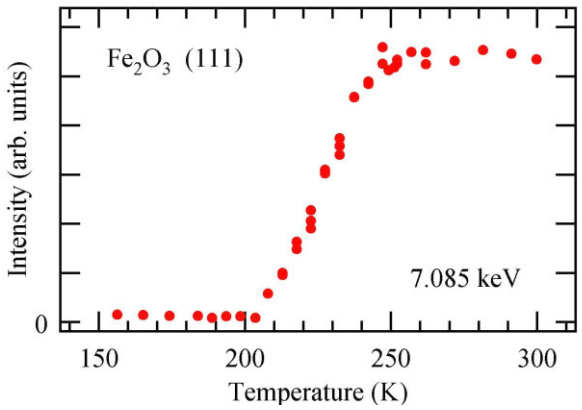

Fig. 1 Temperature dependence of the 111 forbidden reflection at non-resonant energy.

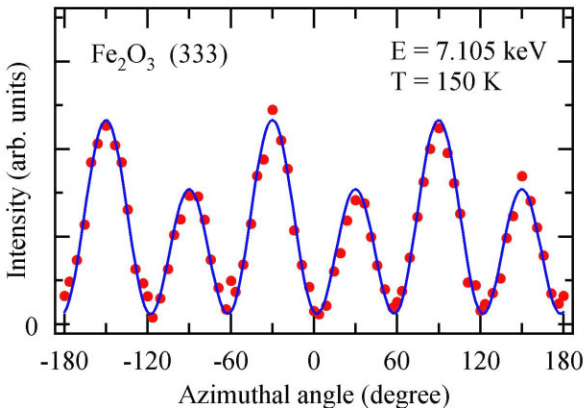

Fig. 2 Azimuthal angle dependence of the 333 forbidden reflection at 150 K and the resonant peak energy.

References

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