Field-induced magnetic order of magnetoplumbite-type cobalt oxide SrCo12O19

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Various physical properties of cobalt oxides have been intensively investigated, which comes from the variety of the electronic states for Co ions. 2+, 3+, and 4+ are stable for the valence of Co ions in oxides. Additionally, the Co3+ ions surrounded by oxygen ions octahedrally can take two different electronic configurations, high-spin state (S = 2) and low-spin state (S = 0).

SrCo12O19 has the magnetoplumbite-type crystal structure as shown in Fig. 1(a) [1]. It consists of the alternate stacking of the SrCo6O11-type blocks and Co3O4-type blocks. From the bond-valence sums, the valences of the Co ions in Co(3) and Co(4) sites are predicted to be 3+ and 2+, respectively [1]. On analogy of SrCo6O11 [2], the Ising-like character is expected for the spins of the Co(3) ions. The uniaxial colossal magnetoresistance was observed in the insulating phase [3]. Ishiwata et al. suggests that the origin of the magnetoresistance is that the charge order in the conduction paths is destabilized by the applied field, and that the uniaxial character of the magnetoresistance is related to the Ising-spins located on Co(3) sites [3]. The magnetic susceptibility has a sharp increase in the case that the magnetic field is perpendicular to the crystallographic c axis at 80 K, which suggests the magnetic long-range order [3].We performed a neutron diffraction experiment at powder diffractometer WOMBAT installed in ANSTO to identify the magnetic state of SrCo12O19. Magnetic peaks indicating the magnetic propagation vector to be (0, 0, 0) were observed below 80 K. The antiferromagnetic order where the ordered moments are located on Co(4) sites reproduces the magnetic peak profile. The interesting point is that the Co(3) ions still have no ordered moments at zero field. In SrCo6O11, the Ising spins are not ordered at zero field, and the ferrimagnetic structure is realized as the field-induced state [4]. The magnetization-field curve of SrCo12O19 at 2 K has the metamagnetic-like anomaly similar with that of SrCo6O11, which indicates that the field-induced states are realized.

Neutron diffraction experiment was performed on High-Intensity Powder Diffractometer WOMBAT installed at ANSTO. 0.9 g of the polycrystalline sample was used. We used the magnet for applying magnetic field. We measured the neutron diffraction patterns at 2 K under the magnetic field of 0, 2, 4, 6, 7, 8, and 9 T. We further measured the pattern at 100 K without the magnetic field in order to obtain the nuclear peak profile for the subtraction.

Neutron diffraction profiles at 2 K under several magnetic fields are shown in Fig. 1(b). The profile at 100 K under zero field is subtracted from these profiles as the background intensities. Five magnetic peaks indexed by (004), (101), (103), (104), (105) were observed at zero field. In addition, the (102) magnetic peak was induced by the magnetic field. Its intensity increases with increasing magnetic field up to 9 T. Meanwhile, the intensity of the (101) peaks decreases a little with increasing magnetic field. It indicates that new magnetic phase with the propagation vector of (0, 0, 0) is induced. The magnetic structure analysis is in progress.

[1] S. Ishiwata et al., J. Solid State Chem. 181, 1273 (2008). [2] S. Ishiwata et al., Phys. Rev. Lett. 98, 217201 (2007). [3] S. Ishiwata et al., Phys. Rev. B 83, 020401 (2011). [4]. T. Saito et al., J. Mag. Mag. Mater. 310, 1584 (2007).

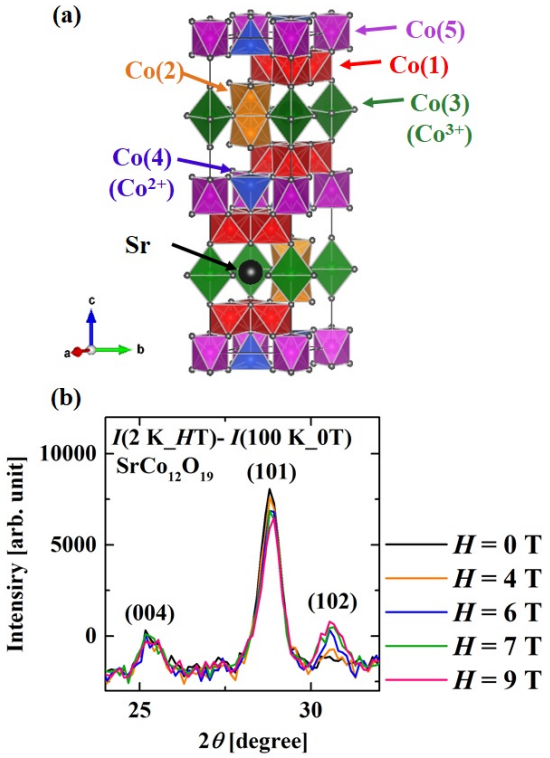

Fig. 1. (a) Crystal structure of SrCo12O19. (b) Neutron diffraction profiles at 2 K under several magnetic fields. The profile at 100 K under zero field is subtracted from the profiles as the background intensities.