Uniaxial-stress control of the volume fraction of magnetic domains in a frustrated magnet CuFe1-xGaxO2 (x=0.018)

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A triangular lattice antiferromagnet $CuFe_{1-x}Ga_xO_2$ exhibits a variety of magnetic phases at low temperatures because of geometrical frustration[1]. Reflecting the trigonal symmetry of the crystal, this system has three magnetic domains labeled as (110)-, ($\bar{2}$10)- and (1$\bar{2}$0)-domains with equivalent three propagation wave vectors, $(q, q, \frac{3}{2})$, $(-2q, q, \frac{3}{2})$ and $(q, -2q, \frac{3}{2})$, respectively, as illustrated in Fig.1(a). Previous x-ray diffraction study[2] revealed structural deformations associated with magnetic phase transitions; the triangular lattice distorts so that the lattice elongates along the magnetic propagation vector. Therefore, it can be expected that uniaxial stress along the [110] direction reduces the volume fraction of the (110)-domain and enhances those of the ($\bar{2}$10)- and (1$\bar{2}$0)-domains. In order to elucidate the effect of uniaxial stress on volume fraction of magnetic domains, we performed neutron diffraction measurements on single crystal $CuFe_{1-x}Ga_xO_2$ with $x = 0.018$, whose ground state is four-sublattice(4SL) magnetic state with the magnetic propagation wave vector of $(\frac{1}{4}, \frac{1}{4}, \frac{3}{2})$.

The sample was cut into thin plate with dimensions of $\sim 4 \times 4 \times 1$ mm^3. Uniaxial stress of 30 MPa was applied on the widest surfaces normal to the [110] direction at room temperature. We used the four-circle neutron diffractometer FONDER installed at JRR-3 in JAEA. The incident neutron beam with wave length of 1.24 Å was obtained by Ge(311) monochromator. The sample in the pressure cell[3] was mounted on a closed-cycle He-gas refrigerator. As clearly seen in Fig.1(a), by applying the uniaxial stress along the [110] direction, the intensity of the 4SL magnetic Bragg reflection in (110)-domain decreases and that in ($\bar{2}$10)-domain increases, suggesting that application of uniaxial stress can easily control the volume fraction of magnetic domains as expected. In addition, as shown in Fig.1(b), we found a quite small peak with the wave number $\sim$ 0.205 of ferroelectric incommensurate (FE-ICM) magnetic state, implying that uniaxial stress induced the FE-ICM ordering in 4SL phase. To elucidate the uniaxial-stress-induced magnetic phase transitions, further investigation is required.

References

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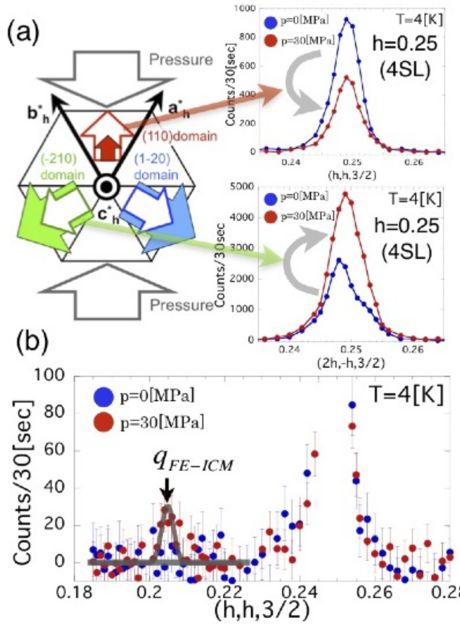

Fig. 1. (a) Schematic drawing of the experimental setup, and typical diffraction profiles of $(h, h, \frac{3}{2})$ and $(2h, -h, \frac{3}{2})$ scans at 4 K. (b) Magnification of diffraction profile of $(h, h, \frac{3}{2})$ scan.