Electric Field Control of Magnetic Correlation in Multiferric Cu(Fe,Al)O_2

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Recently, a magneto-electric multiferroic $CuFeO_2$, in which the ferroelectric phase shows up as a magnetic-field- or impurity-induced phase, has been extensively investigated. The recent experimental works have revealed that the magnetic structure in the ferroelectric phase is a 'proper-screw-type' structure[1], whose spin-helicity corresponds to the polarity of the local ferroelectric polarization emerging along the helical axis.[2] In the previous neutron diffraction measurement on $CuFe_{1-x}Al_xO_2$ at FONDER(T2-2),[3] we have discovered that magnetic diffraction profiles in the ferroelectric phase were sharpened by applying electric field parallel to the helical axis. This implies that the magnetic correlation length in the ferroelectric phase can be controlled by an applied electric field.

In order to investigate the electric field dependence of the magnetic correlation length in detail, in the present experiment, we have performed neutron diffraction measurements on $CuFe_{1-x}Al_xO_2$ ($x = 0.02$) under applied electric fields parallel and perpendicular to the helical axis, using the triple-axis neutron spectrometers HQR(T1-1) and HER(C1-1) installed at JRR-3. As shown in Figs. 1(a) and 1(b), we found that a poling electric field applied parallel to the helical axis sharpens the diffraction profile of $(q, q, 3/2)$ magnetic reflection in the ferroelectric phase, but that applied perpendicular to the helical axis does not. Figure 1(c) shows that the variance of the diffraction profile, which is relevant to the inverse magnetic correlation length, decreases, with increasing poling electric field. This suggests that the average size of the magnetic domains is enlarged by the poling electric field, owing to the one-to-one correspondence between the magnetic and ferroelectric domains, because the poling electric field should enlarges the ferroelectric domains in which the local electric polarization is parallel to it. Note that this electric field dependence of the magnetic correlation length might not be observed not in the typical multiferroics such as $TbMnO_3$, but is clearly observed in $CuFe_{1-x}Al_xO_2$. This is because the magnetic correlation in the ferroelectric phase of $CuFe_{1-x}Al_xO_2$ ($x = 0.02$) is originally disturbed by site-random Al^{3+}-substitutions, and therefore the change in the magnetic correlation length was easily detected by neutron diffraction measurements. For further research, we will investigate the helicity-dependent magnetic correlation by polarized neutron diffraction measurements.

References

[1] T. Nakajima *et al.*: JPSJ **76** 043709 (2007).
[2] T. Nakajima *et al.*: PRB **77** 052401 (2008).
[3] T. Nakajima *et al.*: ISSP-NSL report #328 (2007).

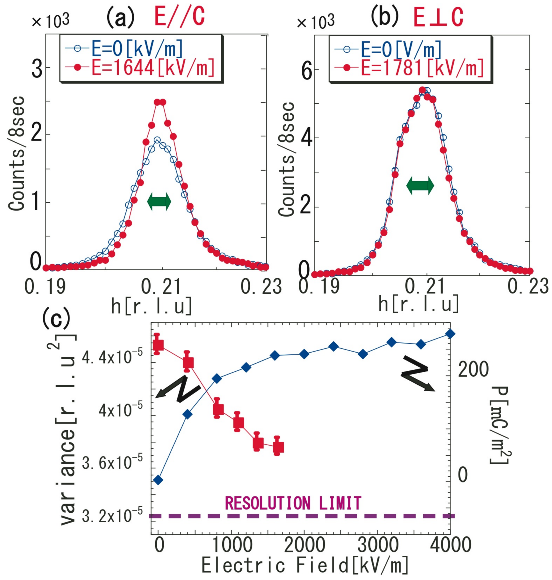

Fig. 1. (a)(b)Diffraction profiles in the ferroelectric phase. Green bar stand for resolution limit. (c)E-field dependence of the variance of diffraction profiles in the ferroelectric phase and the polarization.