18a-C7-4

Successive Phase Transitions and Multiferroic character in Electronic Ferroelectric, RFe$_2$O$_4$ (R = Lu, Yb).

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Charge and spin frustrated system, RFe$_2$O$_4$ is one of the candidates of multiferroic materials because it is considered as an “electronic ferroelectric” having electric polarization arising from polar charge order of divalent and trivalent iron ions [1]. However recently, some questions arose about the existence of the ferroelectricity and the polar charge ordering in this material [2].

Responding to these discussions, we made precise pyroelectric current measurement in YbFe$_2$O$_4$ single crystal and succeeded in proving the presence of electric polarization. Moreover, we found that the temperature variation of (1/3 1/3 integer) diffraction signal (Fig.b) was consistent with that of the polarization (Fig.a). These results strongly support the existence of “electronic ferroelectricity” in RFe$_2$O$_4$. The polar charge ordering is also supported from the space group consideration in the subgroup of R-3m.

This electronic polarization arising from electronic ordering brings many interesting properties, such as magnetoelectric effect and non-linear conductivity. The magnetoelectric effect was cleared out by the analysis with impedance spectroscopy in LuFe$_2$O$_4$. The temperature variations of resistivity, capacitance, relaxation frequency and magnetization all trace out clear hysteresis loop [3]. These results suggest the multiferroic nature in RFe$_2$O$_4$. Non-linear conductivity was also revealed through in-situ measurement of sample resistivity and temperature in YbFe$_2$O$_4$. Below the charge ordering temperature of 350 K the conductivity increased nonlinearly with current [4]. Furthermore this material shows successive transitions around room temperature. We will report detailed investigations for these anomalies.

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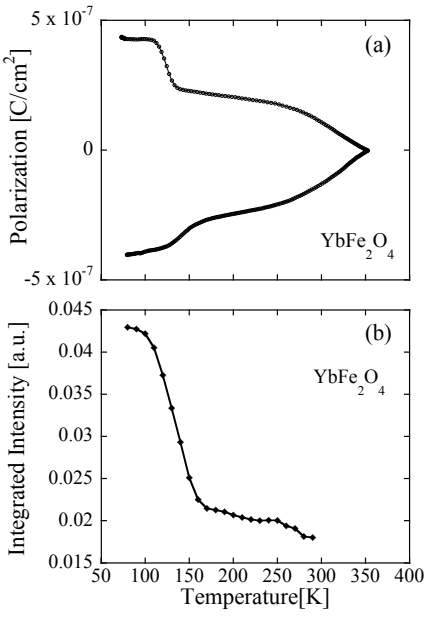

Figure: Temperature variations of the polarization (a) and integrated intensity of (1/3 1/3 integer) diffraction signal (b).