Valence Control of Charge and Orbitals Frustrated System YbFe$_2$O$_4$ with Electrochemical Li$^+$ intercalation.

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YbFe$_2$O$_4$ is the triangular layered oxide in which single layer of [YbO$_2$]$_\infty$ and bilayer of [Fe$_2$O$_4$]$_\infty$ stacks alternately along c-axis. In the [Fe$_2$O$_4$]$_\infty$ equal amounts of divalent and trivalent irons coexist and the geometrical frustration of Fe$^{2+}$ and Fe$^{3+}$ in triangular lattice will appear. It has long discussion about the charge ordering model of this material below 390 K. The charge ordering might be driven from the frustration of charges and the orbital in the iron ions.

We are interested in the controlling of Fe$^{2+}$/Fe$^{3+}$ ratio in this material because the ratio should effect the frustrated interaction of iron ions in the triangular lattice and the appearance of new electronic phase potentially should be expected. In this presentation we report our trial on the controlling the charge state of iron ions in YbFe$_2$O$_4$ powder sample performed by the Li$^+$ ion intercalation with electrochemical method, which is the similar way to Li-ion Battery material.

Fig. 1(a) shows the Fe K-edge XANES spectra of YbFe$_2$O$_4$ where the XANES edge were compared for different Li$^+$ intercalation amount for 0 mAh/g, 100 mAh/g and 200 mAh/g. The XANES edge shifted to the lower energy according to Li$^+$ intercalation. Stoichiometrically, it is considered that whole Fe$^{3+}$ is reduced completely to Fe$^{2+}$ by the Li$^+$ intercalation of 76.8 mAh/g. This XANES data at 100 mAh/g indicates that whole Fe$^{3+}$ was reduced to Fe$^{2+}$ and excess Li$^+$ intercalate to the crystal lattice. Fig. 1(b) shows the variation of XRD peaks (0 0 9) with the Li$^+$ intercalation. With the increase of Li$^+$ amount the peak shifts to the low angle, that indicates the lattice expansion by the coulomb repulsion of Li$^+$ in the lattice.

We also report the variation of fundamental properties such as magnetic, dielectric and electric conduction of YbFe$_2$O$_4$ in accordance with the ratio control of Fe$^{3+}$ and Fe$^{2+}$ and charge frustration by the Li$^+$ intercalation.

Fig. 1(a) XANES signal for Fe K-edge of YbFe$_2$O$_4$ shifts by the Li intercalation.

Fig. 1(b) X-ray diffraction signal of YbFe$_2$O$_4$ (0 0 9) shifts by the Li intercalation.