

## Correlation among magnetic field, spin fluctuation, and electric polarization exhibited by electronic ferroelectric oxide RFe<sub>2</sub>O<sub>4</sub> in nonmagnetic state

Naoshi Ikeda

Grad. Sch. of Env. Life. Nat. Sci. and Tech., Okayama Univ., Okayama, Japan

\*E-mail: ikedan@okayama-u.ac.jp

Rare-earth mixed valence iron oxide RFe<sub>2</sub>O<sub>4</sub> (R=In, Sc, Y, Dy, ..., Lu) was discovered in 70s, and intensive studies were performed in relation to the Verwey type transition irons[1]. Through neutron diffraction and Mössbauer spectroscopy research, the polar charge ordering model was proposed in relation to the spin ordering of iron in this material [2,3,4]. If the electric polarization which arises from the polar electronic order really exist, we could be expected unique and interesting properties which may expand the field of ferroelectricity[5]. With such interests, we performed a Resonant X-ray Scattering (RXS) experiment and found the existence of polar charge ordering in LuFe<sub>2</sub>O<sub>4</sub>, in which the super lattice of Fe<sup>2+</sup> and Fe<sup>3+</sup> loses inversion symmetry in iron triangular lattice[6].

However, the clear indication of the macroscopic spontaneous electric polarization had long been not reported. In 2016, it was reported that the RFe<sub>2</sub>O<sub>4</sub> has the tendency to form the iron vacancy, and when the stoichiometry of the Fe is completed, the long range coherence of the spin and charge order develops[7]. So the investigation of nonlinear optical (Second Harmonic Generation, SHG) measurement for such a stoichiometric crystal successfully found out the existence of the spontaneous electric polarization below 400K[8].

It is expected that the electric polarization arising from the polar electronic ordering may exhibit unique physical properties such as the ultrafast response of electric dipole, magneto-electric interacted phenomena, and so on. In this talk, we present recent research results of such properties of electronic ferroelectric behavior of RFe<sub>2</sub>O<sub>4</sub>[9,10]. Specially, recent discovery of the unique coupling between lattice modulation and magnetic field would be discussed.

This coupling between the magnetic field and the lattice is found just the above magnetic transition temperature. We consider that the phenomena has new but complicated mechanism. We are assuming on the mechanism as that the magnetic field suppresses the spin fluctuation in the short-range spin ordering embedded in iron polar charge ordering region, inhibits the development of the electric polarization, which causes the lattice distortion.

[1] N. Kimizuka, *et al.*, *Solid State Commun.* 15, 1199 (1974).

[2] K. Siratori, *et al.*, *Ferrites Proc. ICF 6*, 703 (1992).

[3] M. Tanaka, *et al.*, *J. Phys. Soc. Jpn.* 58, 1433 (1989).

[4] N. Ikeda, *et al.*, *Ferroelectrics* 161, 111 (1994).

[5] Yasusada Yamada, *J. Korean Phys. Soc.*, 32, S1~S4 (1998)

[6] N. Ikeda, *et al.*, *Nature* 436, 1136 (2005).

[7] K. Fujiwara, *et al.*, *Trans. Mat. Res. Soc. Jpn.* 41, 139 (2016).

[8] K. Fujiwara, *et al.*, *Sci. Rep.* 11, 4277 (2021).

[9] H. Yu, *et al.*, *Materials* 16, 1989 (2023).

[10] H. Yu, *et al.*, *Phys. Rev. Materials* 8, 064402 (2024).