

Ru ドープコバルトフェライト CoFe_2O_4 薄膜における原子価間電荷移動Inter-valence Charge Transfer in a Ru-doped Cobalt Ferrite CoFe_2O_4 Thin Film東大工¹, 東大 CSRN², 東大理³, KEK 物構研⁴○小林 正起^{1,2}, 関 宗俊^{1,2}, 鈴木 雅弘³, 北村 未歩⁴, 藤森 淳³, 堀場 弘司⁴, 組頭 広志⁴,
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To fabricate spintronic devices such as magneto-resistive random-access memory and spin transistors, ferromagnetic semiconductors with the Curie temperatures ($T_C > 300$ K) are needed. Spinel ferrite $M^{2+}\text{Fe}_2\text{O}_4$ ($M = \text{Mg}, \text{Mn}, \text{Co}$, etc) shows semiconducting conductivity at room temperature because the valence state of Fe ion is 3+, and there is no carrier hopping on the B sites. Substituting an ion having the valence higher than 3+ for the cation site M leads to a mixed valence state of $\text{Fe}^{2+}/\text{Fe}^{3+}$ on the B site in $M^{2+}\text{Fe}_2\text{O}_4$, resulting in the increase of the electric conductivity as in the case of Fe_3O_4 . Actually, Ru doping on cobalt ferrite CoFe_2O_4 (CFO) thin films dramatically improves the conductivity [1]. It is expected that this improvement of the conductivity originates from inter-valence charge transfer between the Fe 3d and Ru 4d orbitals; $\text{Fe}^{3+} + \text{Ru}^{3+} \rightarrow \text{Fe}^{2+} + \text{Ru}^{4+}$ [1,2]. In this study, we have conducted x-ray absorption spectroscopy (XAS) and resonant photoemission spectroscopy (RPES) on CFO and $\text{Co}_{0.5}\text{Ru}_{0.5}\text{Fe}_2\text{O}_4$ (CRFO) thin films to investigate the change of the electronic states due to the Ru-doping on CFO.

Figure 1 shows XAS spectra of the CRFO film measured at the Co L_3 and Fe L_3 absorption edges. The decomposition analysis for the Co XAS spectrum suggests that the Co ions are mainly 2+ and there is almost no Co^{3+} component. On the other hand, the decomposition analysis for the Fe spectrum indicates that the Fe^{3+} component coexists with the Fe^{2+} one. These results demonstrate that the mixed valence state of $\text{Fe}^{3+}/\text{Fe}^{2+}$ is realized in the Ru-doped CFO thin film. Additionally, the observation of the Fe- L_3 RPES spectra indicates that the Fe 3d state is hybridized with the Ru 4d state. Based on the experimental findings, it is probable that the inter-valence charge transfer between the Fe and Ru orbitals occurs in CRFO.

References

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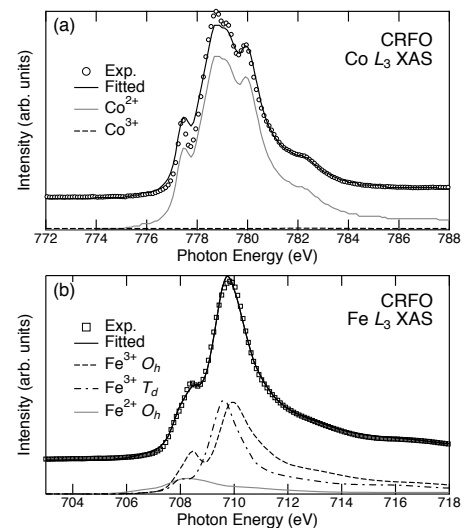


FIG. 1. XAS spectra of a CRFO thin film. (a) Co L_3 XAS spectrum. The spectrum is decomposed assuming the Co^{2+} and Co^{3+} components [3]. (b) Fe L_3 XAS spectrum. These spectra are decomposed assuming $\text{Fe}^{3+} O_h$, $\text{Fe}^{3+} T_d$, and $\text{Fe}^{2+} O_h$ components [4].