ヤーン・テラー効果による$(Cu,Co)Fe_2O_4$微粒子の正方晶化と磁気特性

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Tetragonal distortion and magnetic properties of $(Cu,Co)Fe_2O_4$ particles via Jahn-Teller effect

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Introduction

Cobalt ferrite (CFO) can exhibit large magnetic anisotropy, K_u under certain symmetry reduction conditions. Extraordinarily large K_u of almost 10 Merg/cm^3 obtained by introducing a tetragonal distortion (c/a<1) in the structure has been reported in epitaxially strained CFO thin films [1]. Since epitaxial strain is limited to thin films, development of the material in the form of nanoparticles is necessary for bulk production. The introduction of lattice distortion via Jahn-Teller (JT) effect by substituting Cu^{2+} ion in the B-sites of spinel Fe_3O_4 particles has been proposed [2]. However, due to the oxidation of Fe^{2+} to Fe^{3+} at high temperature, no JT distortion could be confirmed. To explore the JT distortion, the B-site ion of the spinel ferrite has to be highly stable in the divalent state, such as for Co^{2+}. In this study, we report the fabrication of cobalt substituted copper ferrite and the effect of tetragonal distortion on its magnetic properties.

Experimental procedures

$(Co,Cu)Fe_2O_4$ particles were prepared by coprecipiation and flux methods. The aqueous solutions containing Co^{2+}, Cu^{2+}, and Fe^{3+} were mixed with NaOH aqueous solution, and heated at 95℃ for 3 h to form a precipitate. This was then mixed with KBr flux, and heated at 850℃ for 3 hours. The obtained particles were next rinsed with water to remove the KBr flux. Finally, the particles were subjected to heat treatment at 900℃ for 2 h, followed by furnace cooling. Characterizations were performed using x-ray diffraction (XRD) and a vibrating sample magnetometer (VSM) at room temperature.

Results

Figure 1 (a) shows the XRD patterns for $(Cu,Co)Fe_2O_4$ particles after flux treatment. The structure is that of a cubic spinel structure with faint traces of CuO. After heat treatment at 900℃ for 2 h, tetragonal spinel phase could be confirmed (Fig.1 (b)). The single phase showed that both Co and Cu were completely substituted into the spinel structure. Fig. 2 shows the magnetization curves of the particles. It can clearly be seen that the cubic-tetragonal transformation results in a high increase of coercivity. The saturation magnetization values show good agreement with that of an inverse spinel. For the tetragonal $(Cu,Co)Fe_2O_4$ particles, the saturation magnetization was 26 emu/g, whereas the coercivity was about 2000 Oe.

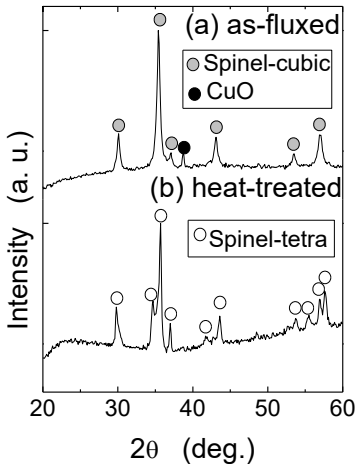

Fig.1. XRD patterns of (a) as-fluxed and (b) heat-treated $(Cu,Co)Fe_2O_4$ particles

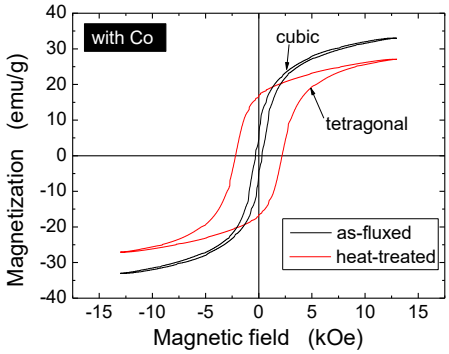

Fig.2. Magnetization curves of the as-fluxed, and heat-treated $(Cu,Co)Fe_2O_4$ particles.

References

[1] T. Niizeki *et al.*, *Appl. Phys. Lett.*, **103**, 162407 (2013).
[2] H. Latiff *et al.*, *IEEE Trans. Magn*, submitted on May 6, 2016.