# TUNING MAGNETIC ANISOTROPY AND CURIE TEMPERATURE OF $L1_0$-FePt GRANULAR FILMS

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## I. INTRODUCTION

$L1_0$-FePt granular films with perpendicular magnetization are attractive candidates for use as recording media for heat-assisted magnetic recording (HAMR) [1]. In HAMR, a medium is heated locally using laser irradiation to the Curie temperature ($T_c$) of FePt. The heating affects a lubricant and carbon overcoat. Some additives to FePt have been examined to reduce $T_c$ while maintaining large $K_u$ [1, 2–4], but $T_c$ reduction degrads $K_u$ considerably. Moreover, carbon and oxide materials are generally used as segregant materials to fabricate a granular structure of FePt. Optimum segregant materials to fabricate a well-segregated granular structure while maintaining large $K_u$ are also important. As described herein, we examined the $T_c$ reduction while maintaining large $K_u$ by substituting some Fe or Pt of FePt with a third material. Moreover, we discuss the magnetic anisotropy of FePt granular media in relation to segregant materials.

## II. ADDITION OF THIRD METALS

After fabricating FePt-X (X: third metals) single crystal films, we examined the relation between $T_c$ and $K_u$. The 10-nm-thick FePt-X films were sputter-deposited on MgO(001) single-crystalline substrates with a 20-nm-thick Pt underlayer at a substrate temperature $T_s$ of 350°C. The film deposition was done using co-sputtering with X targets and Fe-Pt targets with various composition ratios of Fe/Pt. The atomic ratios of Fe, Pt, and X thin films were confirmed using Rutherford backscattering spectrometry (RBS) analysis. Figure 1 presents the relation between values of $T_c$ and $K_u$ of the FePt-X films with X=Cu [5], Mn, and Ru [6]. The relation of $T_c$ and $K_u$ shows a roughly linear trend in all series of films. $T_c$ of the FePtRu films decreased more steadily than that of the other series of films. These results demonstrate that Ru addition can achieve low $T_c$ while maintaining $K_u$ as higher than Mn and Cu addition. Figure 2 depicts relations of anisotropy field $H_k$ (= $2K_u/M_s$, where $M_s$ denotes saturation magnetization) and $M_s$ of these films. Results show that Ru addition decreased $H_k$ moderately, but $M_s$ decreased rapidly. By contrast, Cu and Mn addition drastically decreased $H_k$. The rapid decrease of $T_c$ by Ru addition occurs because of a sharp decrease of $M_s$: $T_c$ is related to the magnitude of moments. Ru is a noble metal and is therefore not very reactive to oxygen, which is suitable for fabrication of granular films by adding oxide segregants.

## III. SEGREGANT MATERIALS

Stacked films consisting of a FePt-oxide upper layer and a FePt-C template layer are effective to promote columnar growth and $L1_0$-ordering of FePt grains maintaining high $K_u$ [7,8]. Figure 3 shows magnetization loops of FePt-25vol.% oxide (3 nm)/FePt-40vol.%C(2 nm) stacked films comprising various oxide materials. These films were fabricated using co-sputtering on MgO underlayers at a substrate temperature of 450°C in identical deposition conditions. All films are perpendicular films, but marked differences in magnetization curves were observed. These differences are related to segregation structures and $K_u$. Figure 4 presents values of $K_u$ as a function of the electronegativity of oxide materials for these

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stacked films. The $K_u$ of FePt-$GeO_2$/FePt-C stacked films is 2.1 × $10^7$ erg/$cm^3$, which corresponds to 3.0 × $10^7$ erg/$cm^3$ of FePt grains [9]. However, $K_u$ decreased as electronegativity decreased, implying that the electronegativity of oxide segregants influences the degree of FePt ordering.

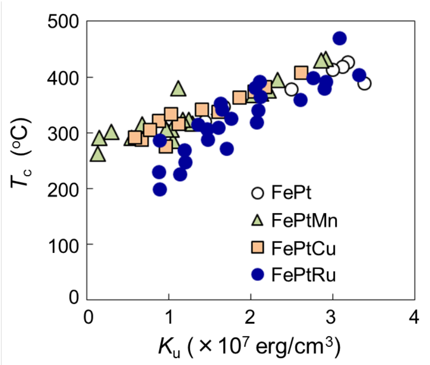


Fig. 1. Relation between values of $T_c$ and $K_u$ for FePtX (X=Mn, Cu, and Ru) films.

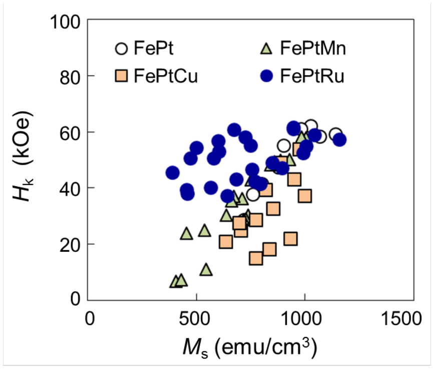


Fig. 2. Relation between values of $H_k$ and $M_s$ for FePtX (X=Mn, Cu, and Ru) films.

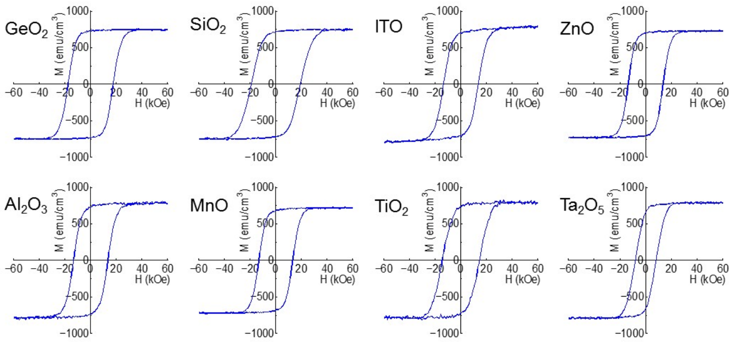


Fig. 3. Magnetization loops for FePt-25 vol.% oxide (3 nm)/FePt -40 vol.% C (2 nm) stacked films with various oxide materials.

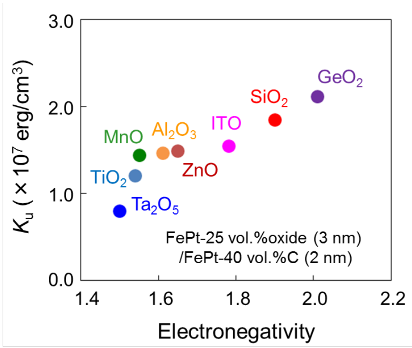


Fig. 4. Values of $K_u$ as a function of electronegativity.

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