# Phase Transformation Behavior of FePtCu Nanoparticles

Soon-Gil Kim*, Chang-Woo Lee, and Jai-Sung Lee
Department of Metallurgy and Materials Science, Hanyang University, Ansan 426-791, Korea

## 1. Introduction

According to enhancements of multimedia industry, high-density magnetic recording media which has large capacity with shorter access time has been developed. Decrease in crystallite size for increase of recording density brought out thermally unstable situation (superparamagnetic behavior) because of lower magneto-crystallite anisotropy energy. Achievable data densities will be restricted by fundamental physical phenomena such as bit instability due to superparamagnetism. $L1_0$ materials (FePt or CoPt) with higher magneto-crystallite anisotropy energy have been attractive as ultrahigh-density magnetic recording media. In the case of FePt nanoparticles synthesized by polyol process, the ordered phase with strong coercivity depends on the annealing temperature so the particles must be heated to nearly 580°C. But FePt nanoparticles were coalesced in that temperature. Thus, it is suggested that annealing temperature be lower than 550°C to protect particle coalescence by using additives. In practice, many scientists have reported on the effect of additives (Ag, Au, etc.) on the thermal ordering of self-assembled $L1_0$ nanoparticles.

In the present work, we reported on the synthesis of FePtCu nanoparticles by chemical reduction method. This reduction method of Fe acetylacetonate was more stable and easier control than thermal decomposition of $Fe(CO)_5$ because of its high toxicity and flammability at room temperature. Also, phase transformation of as-synthesized FePtCu nanoparticles from disordered fcc to order fct and the effect of the Cu on the phase transformation temperature were analyzed by DSC (differential scanning calorimeter).

## 2. Experimental

In order to synthesize FePtCu nanoparticles, metal acetylacetonates for each metal element were used as precursors. Chemical synthesis began with mixture of Pt-, Fe-, and Cu acetylacetonate. And then, mixture of 1,2-hexadecanediol, octyl ether, oleic acid, and oleyl amine were additionally fed into the precursor and then heated at 300°C for 30 min. Finally black-colored ultrafine precipitates were obtained by centrifugal separation.

The elemental composition of FePtCu nanoparticles were analyzed by EDS (energy dispersive X-ray spectroscopy). Phase-transformation temperature from disordered fcc to ordered fct has been investigated using DSC in Ar atmosphere. In the DSC measurements, temperature was raised to 700°C at a rate of 10°C/min. Average diameter and morphology of disordered and ordered FePtCu nanoparticles were shown by TEM (transmission electron microscopy). Magnetic properties were analyzed by VSM (vibration sample magnetometer) at 298K.

## 3. Results, discussion and conclusion

The EDS study revealed that the final atomic ratio of Cu depended on initial Cu acetylacetonate concentration. In the Cu composition range of 0 to 46%, phase transformation was observed between 600°C and 700°C. This showed that phase transformation of FePtCu nanoparticles occurred at higher temperature comparing to FePt nanoparticles. Considering Ag and Au, they were precipitated in annealed FePt nanoparticles, which were clearly analyzed by X-ray diffraction. Annealing temperature of FePtAg and FePtAu nanoparticles was lower than that of FePt nanoparticles.

However, FePtCu nanoparticles in this study showed different results, which caused higher phase transformation temperature than FePt nanoparticles. The reason is explained by the role of Cu in FePtCu nanoparticles. It can be expected that Cu has remained in the particles without being precipitated. Because we found no evidence of precipitation showing the Cu [111] diffraction peak (at $2\theta$ = 43.3) when the powder were heat treated.

As-synthesized FePtCu nanoparticles were 3 nm in size and spherical. When they were annealed at 700°C, FePtCu nanoparticles were grown up to 10 nm. Also, annealed particles were agglomerated due to the highly ordered phase. From the magnetic properties measured by VSM (1 T), as-synthesized particles showed soft magnetic property and ferromagnetic property appeared after annealing. Coercivity of annealed FePtCu nanoparticles depended on Cu composition to FePt. The maximum coercivity of particles was 6.6 kOe at Cu atomic percent of 28%.

In summary, we have found that the annealing temperature for ordering could be significantly higher up to ~650°C by addition of Cu. This annealing temperature condition was closely related to smaller ionic radius of Cu than Ag and Au.

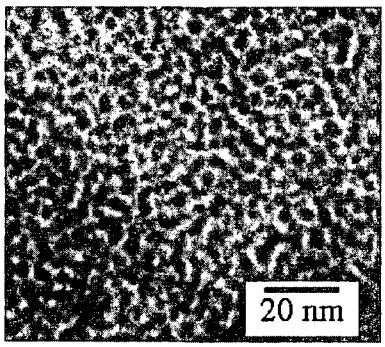


Fig. 1. TEM micrograph of FePtCu nanoparticles dispersed in n-hexane.

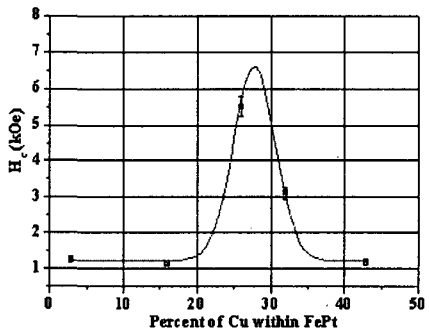


Fig 2. The composition-dependent coercivity of FePtCu nanoparticles after heat-treatment at 700°C for 30min in Ar atmosphere.