

## Synthesis and Characteristics of FePt Nanopowder by Chemical Vapor Condensation Process

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### Abstract

*FePt binary-alloy nanopowder has been successfully synthesized by chemical vapor condensation process with two metal organic precursors, i.e., iron pentacarbonyl and platinum acetylacetonate. Average particle size of the powder was less than 50 nm with very narrow size distribution, revealing high dispersion capability. Characteristics of the powder could be controlled by changing process parameters such as reaction temperature, chamber pressure, as well as gas flow rate. Magnetic properties of the synthesized FePt nanopowder were investigated and analyzed in terms of the powder characteristics.*

**Keywords :** FePt nanopowder, Chemical vapor condensation, Nano-alloy, Magnetic properties

### 1. Introduction

Recently, FePt nanoparticles have been studied intensively because have great potential as magnetic materials for high density data storage media. The L1<sub>0</sub> type FePt has a very high magnetocrystalline anisotropy ( $K_A \sim 6.6 \cdot 10^7 \text{ erg/cm}^3$ ), high coercivity and chemical stability [1,2].

Several methods have been developed to produce thin particle films with controlled thicknesses that are more resistant to sintering during annealing [3-6]. Sun *et. al.* have prepared spherical FePt nanoparticles by simultaneous reduction of Pt(acac)<sub>2</sub> with 1,2-hexadecanodiol and thermal decomposition of Fe(CO)<sub>5</sub> in the presence of mixed surfactants [2]. Recently, preparation of the monodisperse FePt nanoparticles via simultaneous reduction of FeCl<sub>2</sub> or Fe(acac)<sub>3</sub> and Pt(acac)<sub>2</sub> has been reported [7,8]. Particle size produced by the polyol method is generally about 3-5 nm.

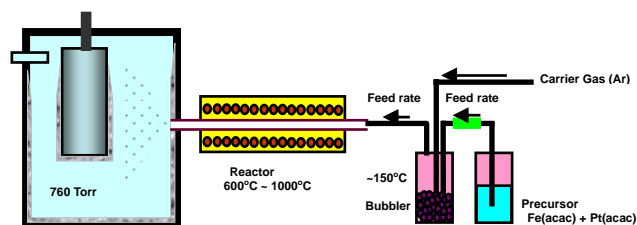
In bulk FePt alloys, an annealing around 1273 K is needed to transform the disordered face-centered cubic (A1) structure to the ordered tetragonal L1<sub>0</sub> structure. In thin films and nanoparticles, the transformation temperature is significantly reduced ( $\sim 800 \text{ K}$ ) due to the enhanced diffusion during film growth on heated substrates. However, such annealing leads to subsequent crystallite growth and concurring agglomeration of the previously separated nanoparticles on the substrate [9-11].

In order to avoid these difficulties, we employ the technique that allows us to prepare and sinter (or anneal) the FePt nanoparticles in the gas-phase state prior to condensation. In this paper, we focused on the microstructural characterization of such gas-phase prepared FePt particles with the goal to obtain monodisperse fraction of L1<sub>0</sub> ordered FePt nanoparticles.

### 2. Experimental

The basic setup for the synthesis of FePt nanoparticles by CVC is shown in Fig. 1. To produce FePt nanoparticles, Ar carrier gas was fed through a heated bubbling unit containing solid iron acetylacetonate (Fe(acac)) and platinum acetylacetonate (Pt(acac)) precursors. The carrier gas entrained precursor vapors and passed through a reactor in which the precursors pyrolyzed and condensed into clusters or particles. The synthesized particles were collected from a rotating chiller cooled by liquid nitrogen. The reactor was a tubular furnace uniformly heated 600 ~ 1000 °C.

Microstructural investigation on the particles synthesized was performed with a HRTEM. Phases in the particles were identified by Cu *K $\alpha$*  X-ray diffraction. Chemical composition of the particles was analyzed with a SEM-EDS. Magnetic properties of the powder synthesized were measured with a VSM at room temperature with maximum applied field of 2.0 T.

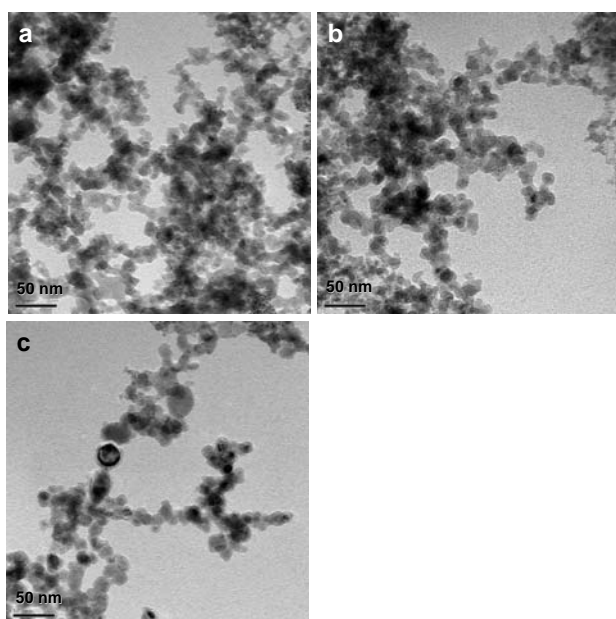


**Fig. 1. Schematic diagram of chemical vapor condensation process.**

### 3. Results and Discussion

Fig. 2 shows TEM micrographs of the FePt nanoparticles synthesized by CVC process at different reaction temperatures. The particles were spherical and slightly agglomerated each other. The particle size increased with the increase of reaction temperature: The average size of the particles was 15 nm at 600 °C, 20 nm at 800 °C, and 30 nm at 1000 °C. Such growth of the particles is mainly due to the accelerated sintering behavior at higher temperature. That is, at higher temperature, the collision between condensed nanoparticles is much increased due to high convection of gas phases, resulting in the growth of the particles agglomerated each other. The chain-shaped morphology of relatively coarse particles in Fig. 2(c) indicates such sintering behavior of vapor phases at high temperature.

It was found that, by X-ray diffraction analysis, the particles synthesized at higher temperature mostly consisted of FePt ( $L1_0$ ) phase whereas those synthesized at lower temperature contained considerable amount of Fe and Pt.



**Fig. 2.** TEM micrographs of FePt nanoparticles synthesized at 760 torr at (a) 600 °C, (b) 700 °C, and (c) 1000 °C by chemical vapor condensation process.

**Table 1.** Composition of FePt nanopowder synthesized at different reaction temperatures.

Temperature(°C)	Composition (wt %)		
	Fe	Pt	Total
600	94.9	5.1	100
800	85.7	14.3	100
1000	85.7	14.3	100

As listed in Table 1, the amount of Pt in FePt nanoparticles was saturated to 14.3 wt% at and above 800 °C. The low content of Pt in the powder synthesized at 600 °C was thought to be due to insufficient decomposition of Pt precursor at this low temperature. Coercivity of the powder synthesized was all about 20 Oe, indicating that the particle size is considerably smaller than that of the single domain size.

### 4. Summary

FePt nanoparticles were successfully fabricated by chemical vapor condensation process. The particles were spherical and slightly agglomerated. The average particle size of FePt powder increased from 15 nm to 30 nm with the increase of reaction temperatures. The amount of Pt in the FePt nanoparticles synthesized was relative low.

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