Anisotropy Distribution in Self-Assembled FePt Nanoparticles with Partial Chemical Ordering


_MINT Center, The University of Alabama_

This project was funded by NSF MRSEC Grant No. DMR-9809423

Structural Transition of FePt Nanoparticles

Disordered with cubic anisotropy

Ordered with uniaxial anisotropy

annealing

K_u: ~10^7 erg/cc

fcc structure
Only Fundamental Peaks (111), (200), ...

fct structure
Fundamental & Superstructural Peaks (111), (200), (002), ...; (001), (110), ...

Fe atom
Pt atom

THE UNIVERSITY OF ALABAMA

Center for Materials for Information Technology
an NSF Materials Science and Engineering Center
Structure Characterization

XRD patterns for as-made and partially ordered samples. P is the ordering parameter. (*) indicates superlattice peaks.
TEM Observations

TEM images of self-assembled FePt nanoparticles on SiN grids: (a) as-made and (b) annealed at 580°C for 30 minutes. The particle diameters were 4 nm.
M-H Loops

FePt@500°C

FePt@520°C

FePt@550°C

FePt@580°C

DCD
Irreversal Susceptibility

The irreversal susceptibility reveals broad and narrow distribution of anisotropy for FePt nanoparticles with low and high chemical ordering, respectively.
Calculated Coercivity Ratio

Fig. 1. Dependence of coercivity factor on anisotropy distribution width and mean field interaction.

Calculated coercivity ratio using a mean field Stoner-Wohlfarth model assuming a log-normal anisotropy distribution.

\[ h = h_{\text{applied}} + \alpha m, \]
\[ h = H/H_{k0}, \ m = M/M_s. \]
Effect of Saturation Field on Coercivity Ratio

Left: Measured coercivity ratio versus saturation field for FePt nanoparticles annealed at different temperature.
Right: Calculated coercivity ratio agrees well with measurements.
Summary

• Self-assembled FePt nanoparticles of diameter ~ 4 nm were synthesized and annealed at different temperatures, resulting in a range of chemical ordering.
• $H_C$ increases up to 12 kOe with annealing temperature up to 580°C. The irreversal susceptibility suggests increasing anisotropy width with decreasing chemical ordering.
• Large coercivity ratios, $H_{CR}/H_C$, were observed in partially ordered samples due to the broad anisotropy distribution.
• The dependence of coercivity ratio on anisotropy distribution width was confirmed using a mean field Stoner-Wohlfarth model.