Synthesis, Self-Assembly and Magnetic Properties of $L1_0$ Phases, FePt, FeCoPt, CoPt and FePd Nanoparticles

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Project Objectives

Repeat the Synthesis and Self-Assembly of FePt Nanoparticles

- Understand the magnetic behavior of these particles (collaboration with J. W. Harrell)

Extend this particle chemistry to the synthesis of other $L1_0$ phases

- FePd, CoPt and FeCoPt

Learn how to control the magnetic anisotropy

- Annealing in either longitudinal or perpendicular magnetic fields

Synthesis of FeCoPt Nanoparticles

$Pt(acac)_2$ (200 mg, 0.500 mmol) + $Co(acac)_2$ + 1,2-hexandecane diol (390 mg, 1.5 mmol) + dioctylether (20 mL)

↓ (heat to 100°C under nitrogen)

Add $Fe(CO)_5$ (0.13 mL, ~1 mmol) + oleic acid (0.16 mL) + oleylamine (0.17 mL)

↓ (reflux at 286°C for 30 min)

Particle Dispersion

↓ (add 40 mL ethanol)

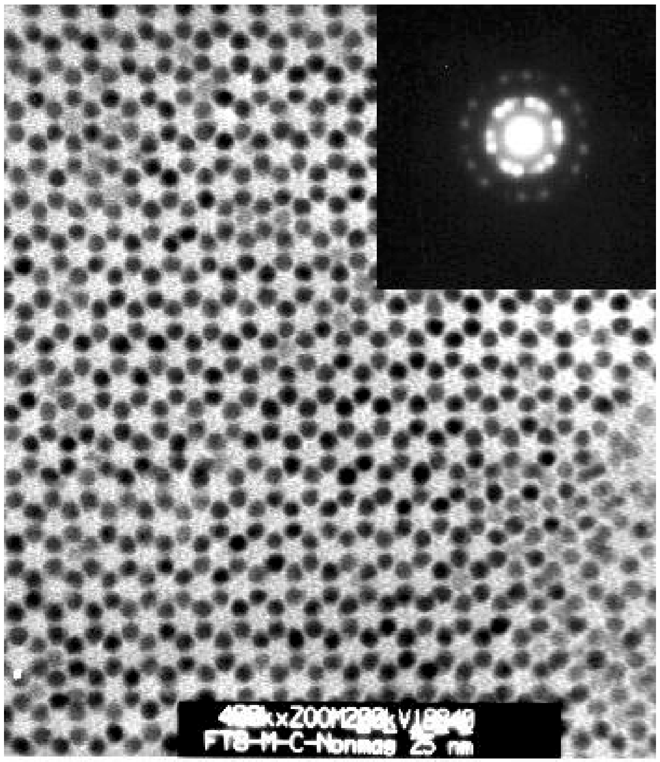
Isolate Particles by Centrifuging

Chemical Composition of FeCoPt Nanoparticles

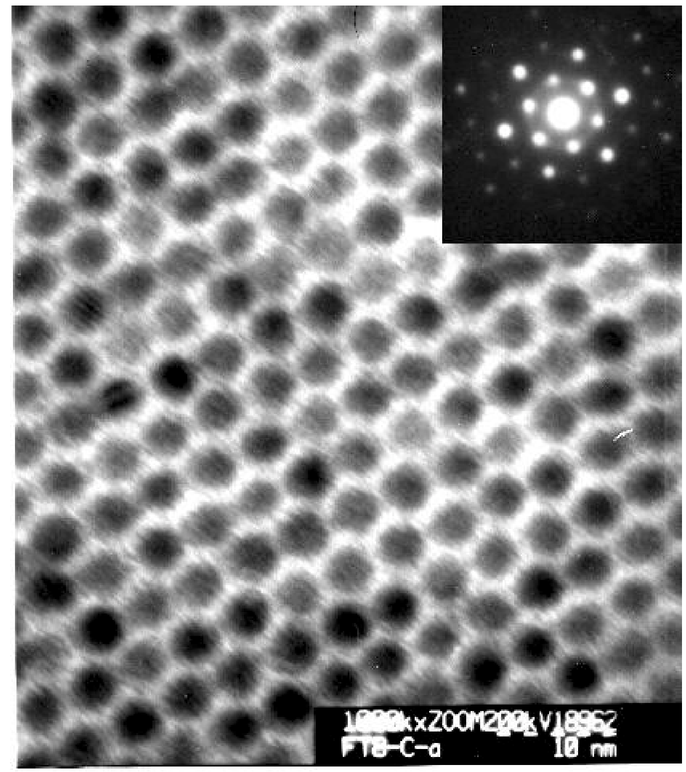
EDS Analysis of As-Prepared Particles (mole percent)

Batch		Fe	Co	Pt	Diameter (nm)
1	Charged	67	0	33	3.5
	Found	48	0	52	
2	Charged	63	6	31	3.4
	Found	49	7	44	
3	Charged	57	14	29	3.5
	Found	40	17	43	
4	Charged	47	21	32	3.6
	Found	34	19	47	
5	Charged	37.5	25	37.5	3.6
	Found	23	27	50	

$Fe_{49}Co_7Pt_{44}$ Nanoparticles



Thin film: "Honeycomb" array comes from ABAB stacking of the particles



Thick film: hexagonal close-packed array comes from ABC stacking

Coercivity of Annealed of FeCoPt

Temperature (°C)	550	600	700	700	700
Time (hr)	0.5	0.5	0.5	1.0	3.0
$Fe_{48}Pt_{52}$	3,970	6,500	>11,600*		
$Fe_{49}Co_7Pt_{44}$	2,430	4,500	8,700		
$Fe_{40}Co_{17}Pt_{43}$		3,800	6,500		
$Fe_{34}Co_{19}Pt_{47}$		2,180		6,630	6,990
$Fe_{23}Co_{27}Pt_{50}$		242		4,590	9,090

* Minor loop

CoPt Nanoparticles

Particle Synthesis

Pt(acac)$_2$ (0.500 mmol) +

1,2-hexandecane diol (1.50 mmol) +

dioctylether (20 mL)

↓ (heat to 100°C under nitrogen)

Add $Co(CO)_3NO$ (1.00 mmol) +

oleic acid (0.5 mmol) +

oleylamine (0.5 mmol)

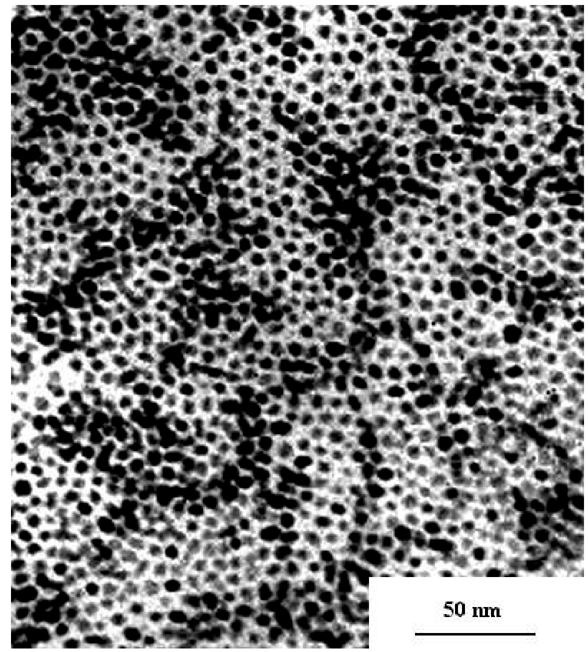
↓ (reflux at 286°C for 30 min)

Black Particle Dispersion

↓ (add 20 mL ethanol)

Isolate Particles by Centrifuging

$Co_{48}Pt_{52}$



Average particle size about 7 nm

Need to further refine the particle size distribution in order to get self-assembly

FePd Nanoparticles

Particle Synthesis

Pd(acac)$_2$ (0.500 mmol) +

1,2-hexandecane diol (390 mg, 1.5 mmol)

+ dioctylether (20 mL)

↓ (heat to 100°C under nitrogen)

Add Fe(CO)$_5$ (0.75 mmol) +

oleic acid (0.50 mmol) +

oleylamine (0.50 mmol)

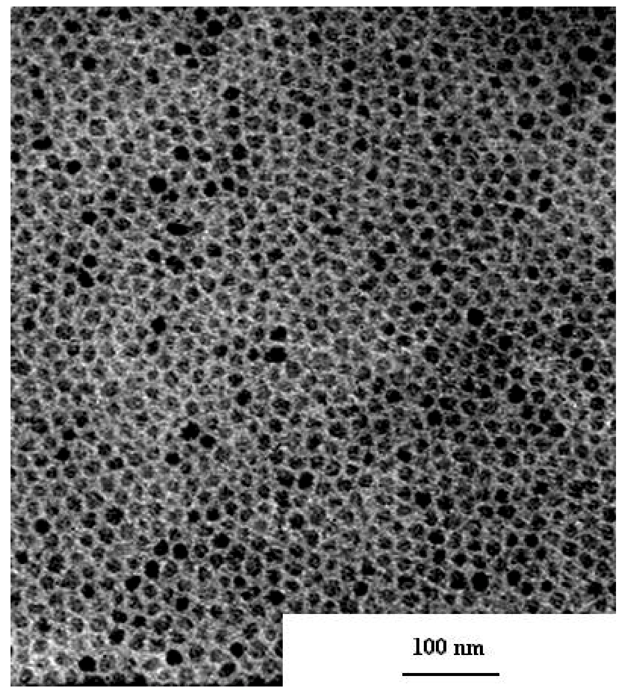
↓ (reflux at 286°C for 30 min)

Particle Dispersion

↓ (add 40 mL ethanol)

Isolate Particles by Centrifuging

$Fe_{50}Pd_{50}$



Average particle size about 11 nm

Need to further refine the particle size distribution in order to get self-assembly

Conclusions

The procedure published by Sun, et al* has great utility

We have used their procedure to prepare FePt nanoparticles

We have modified their procedure to prepare FeCoPt, CoPt and FePd nanoparticles

We have demonstrated the FeCoPt particles self-assemble into hexagonal close-packed arrays in a manner similar to FePt nanoparticles

The addition of Co into FePt appear to lower the coercivity of the annealed films.

We have not demonstrated self-assembly of the CoPt or the FePd particles, because of the broad particle size distribution.

This particle chemistry provide new opportunities to develop granular media for future high density media hard drive systems.

* Shousheng Sun, C. B. Murray, D. Weller, L.Folks and A. Moser *Science*, 287, 1989-1991, 2000