MMM 2008
53rd Annual Conference on Magnetism and Magnetic Materials
November 10 - 14, 2008 - Austin, Texas

Magnetic Properties of $Fe_xPt_yAu_{1-x-y}$ Nanoparticles

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Introduction

- Monodisperse $L1_0$ FePt nanoparticles are ideal candidates for future data storage media.
- Chemically synthesized fcc FePt nanoparticles can be easily sysnthesized by the method reported by Sun *et.al*.
- However, fcc to $L1_0$ phase can only be obtained after annealing FePt nanoparticles above 500°C which causes particle sintering and agglomeration.
- To avoid the sintering, several techniques have been used like

  Doping in FePt nanoparticles

  Salt Matrix Annealing

  SiO_2 Nanoreactor Method etc.

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Motivation

- Au doped FePt nanoparticles has resulted in a decrease in the transition temperature as high as 150˚C and the coercivity up to 10 kOe can be obtained after annealing at 500˚C compared to 2 kOe from FePt nanoparticles.
- However, the saturation magnetization of FePtAu nanoparticles is significantly lower than pure FePt nanoparticles due to the non-magnetic nature of the Au.
- Also, the promoted particles sintering in FePtAu nanoparticles due to the Au complicates the true effect of doping.

Synthesis of FePtAu Nanoparticles

$Pt(acac)_2$

$Au(ac)_3$

Phenyl Ether

~~Reducing Agent~~

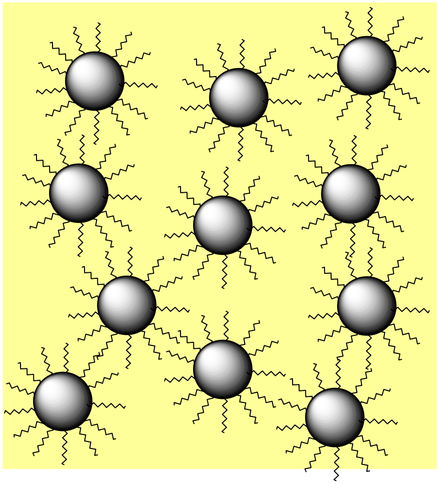
~ 80°C →

Oleic Acid

$Fe(CO)_5$

Oleylamine

~ 265°C →



FePtAu Nanoparticles

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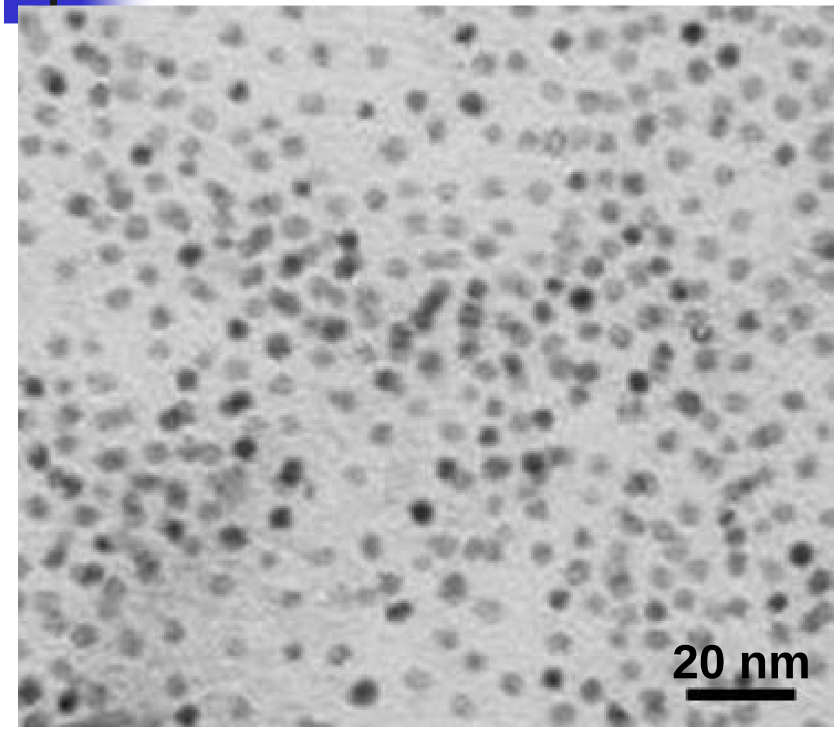
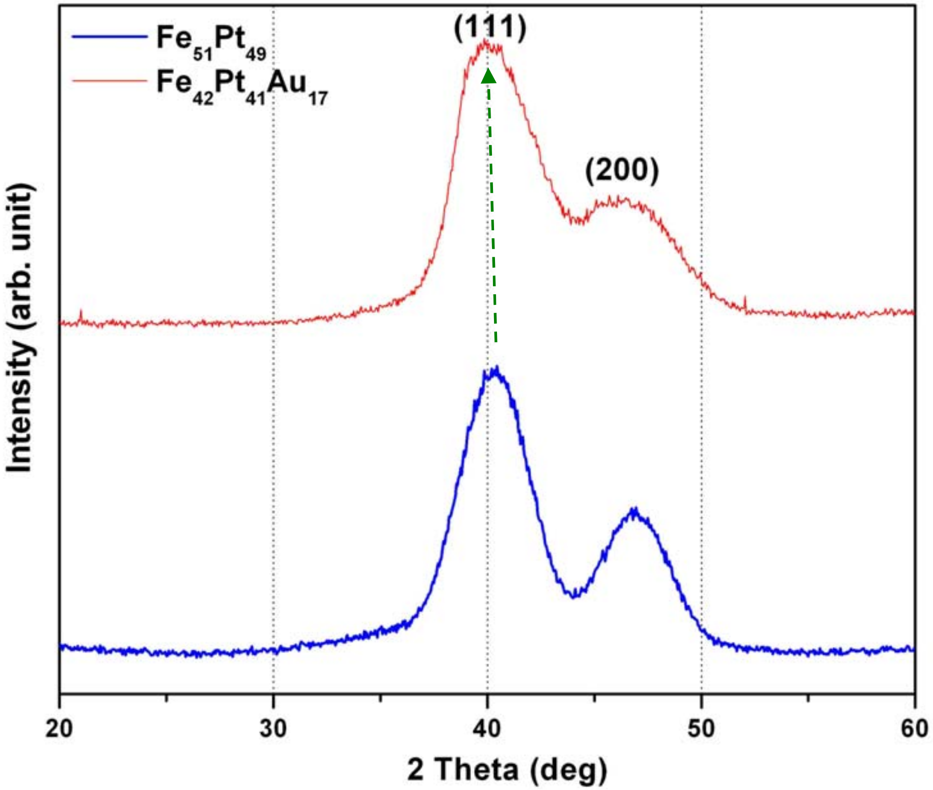
S. Kang *et. al.*, J Appl. Phys. 95, 6744 (2004).

TEM and XRD of as-synthesized FePtAu nanoparticles



Average Particle Size ~ 3.5 nm
Crystal Structure – FCC



Shift in (111) peak of FePtAu nanoparticles indicate the lattice expansion due to addition of Au in FePt.

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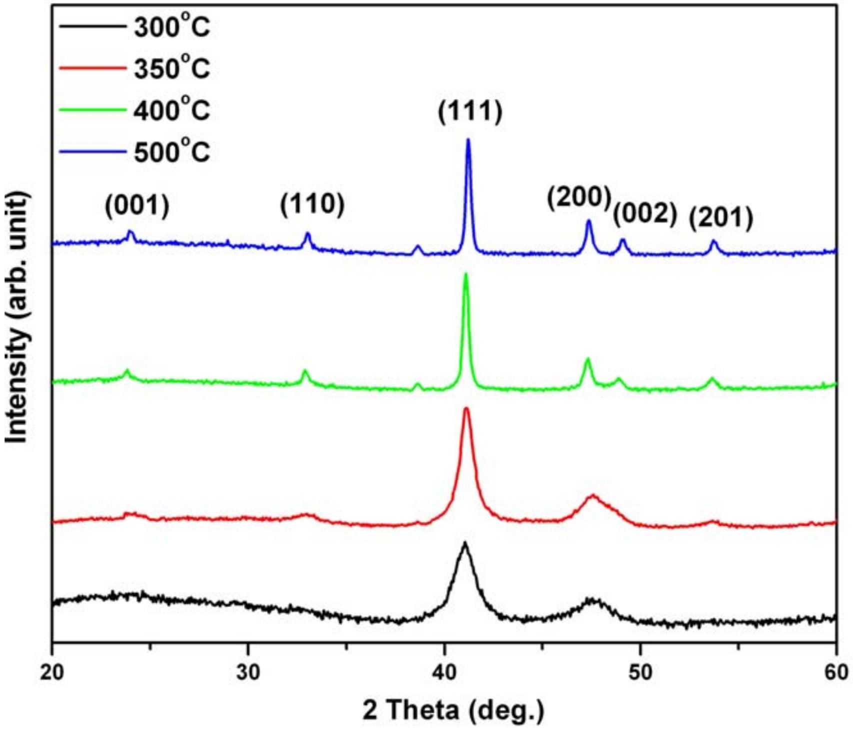
XRD of FePtAu nanoparticles at different annealing temperatures

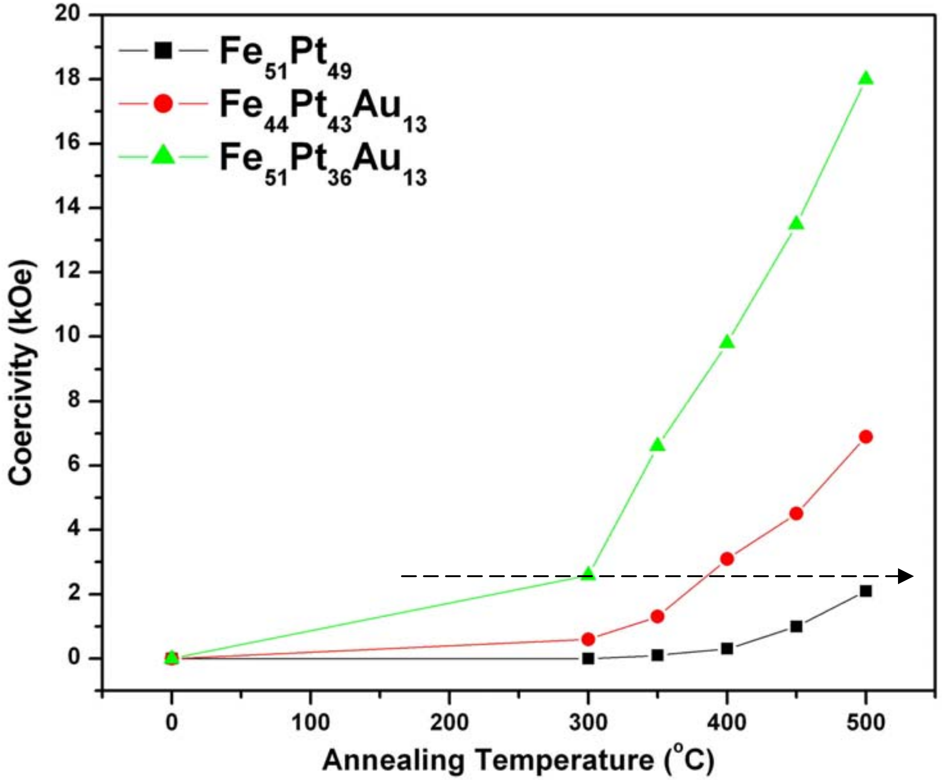


- Appearance of weaker superlattice peaks starts at temperatures as low as 350°C.

Design of Experiment

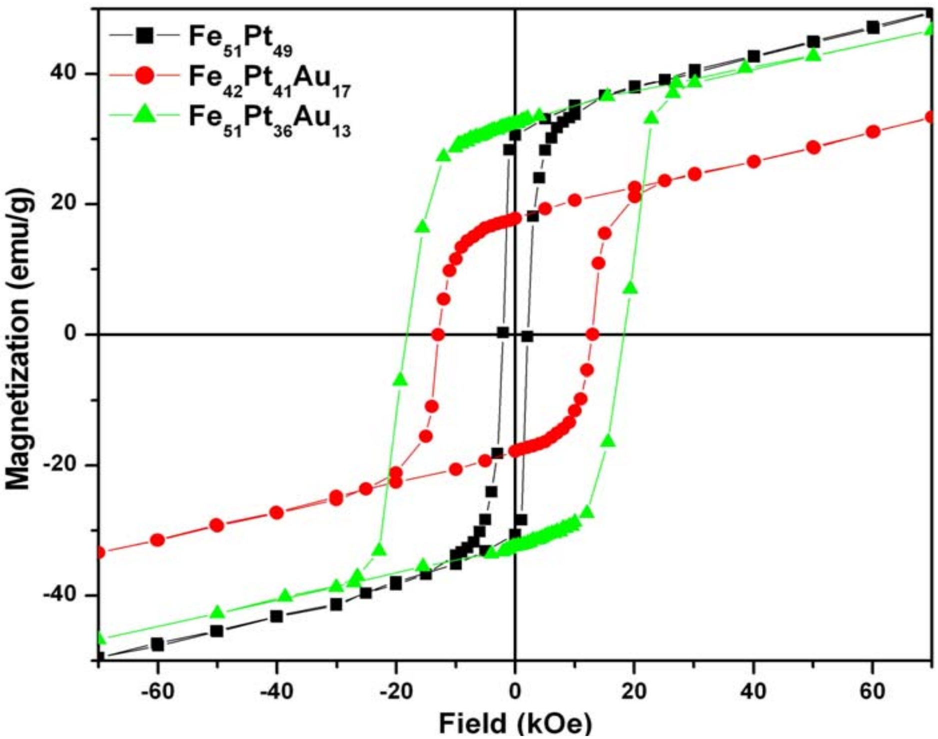
$Fe(CO)_5$ (mmol)	Pt(acac)$_2$ (mmol)	Au(ac)$_3$ (mmol)	Composition of $Fe_xPt_yAu_{1-x-y}$	Coercivity (kOe) at 500°C	Saturation Magnetization (emu/g) at 500°C
1.0	0.5	**0.0**	$Fe_{51}Pt_{49}$	2.0	50
1.0	0.5	**0.1**	$Fe_{46}Pt_{45}Au_9$	3.3	43
1.0	0.5	**0.15**	$Fe_{44}Pt_{43}Au_{13}$	6.9	38
1.0	0.5	**0.2**	$Fe_{42}Pt_{41}Au_{17}$	13	33
1.0	0.5	**0.25**	$Fe_{38}Pt_{37}Au_{23}$	7.5	27
1.0	0.5	**0.3**	$Fe_{35}Pt_{35}Au_{30}$	3.5	21
1.0	0.5	0.2	$Fe_{42}Pt_{41}Au_{17}$	13	33
1.2	0.5	0.2	$Fe_{46}Pt_{39}Au_{15}$	14.8	39
1.4	0.5	0.2	$Fe_{51}Pt_{36}Au_{13}$	18	47
1.6	0.5	0.2	$Fe_{55}Pt_{33}Au_{12}$	15.5	53
1.8	0.5	0.2	$Fe_{60}Pt_{30}Au_{10}$	4.5	61

Magnetic Properties of $Fe_xPt_yAu_{100-x-y}$ nanoparticles



- The coercivity of $Fe_{51}Pt_{36}Au_{13}$ nanoparticles after annealing at 300°C was 2.6 kOe which suggests the phase transition temperature from fcc to $L1_0$ structure was reduced by more than 200°C.

Hysteresis loops of annealed FePt and FePtAu nanoparticles



Annealing condition - 500°C for 1 hour.

- The similar values of saturation magnetization of $Fe_{51}Pt_{36}Au_{13}$ and $Fe_{51}Pt_{49}$ nanoparticles implies that Au doping enhances the coercivity without almost any sacrifice in saturation magnetization.

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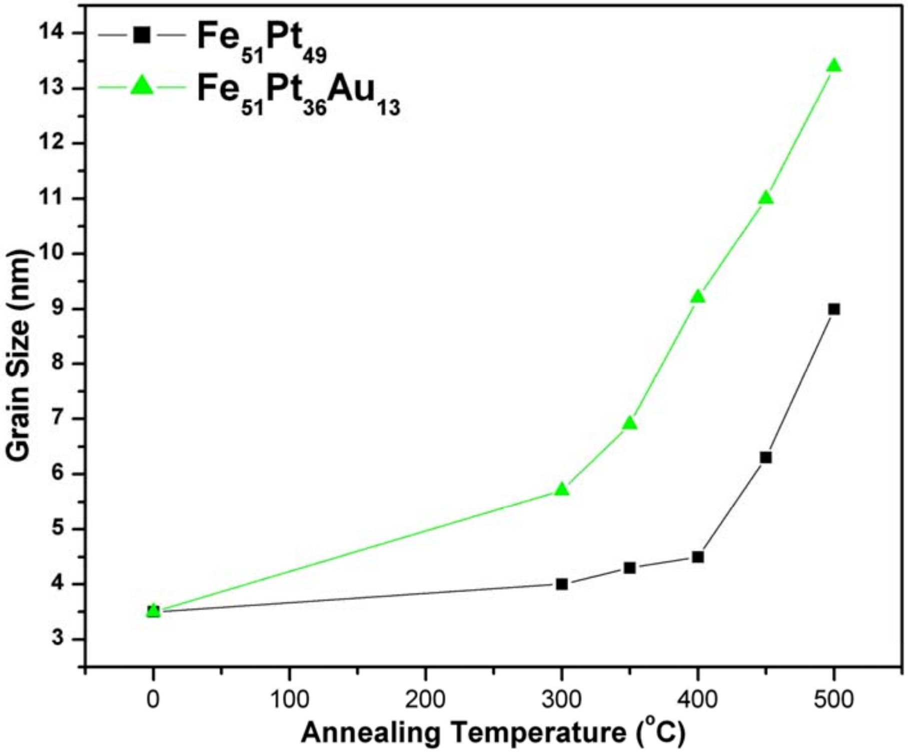
Grain size dependence of FePt and $Fe_{51}Pt_{36}Au_{13}$ nanoparticles



- The grain size was calculated from the XRD curves of annealed nanoparticles using Scherrer's formula.
- The higher grain size of $Fe_{51}Pt_{36}Au_{13}$ indicates that presence of Au promoted the particle sintering.

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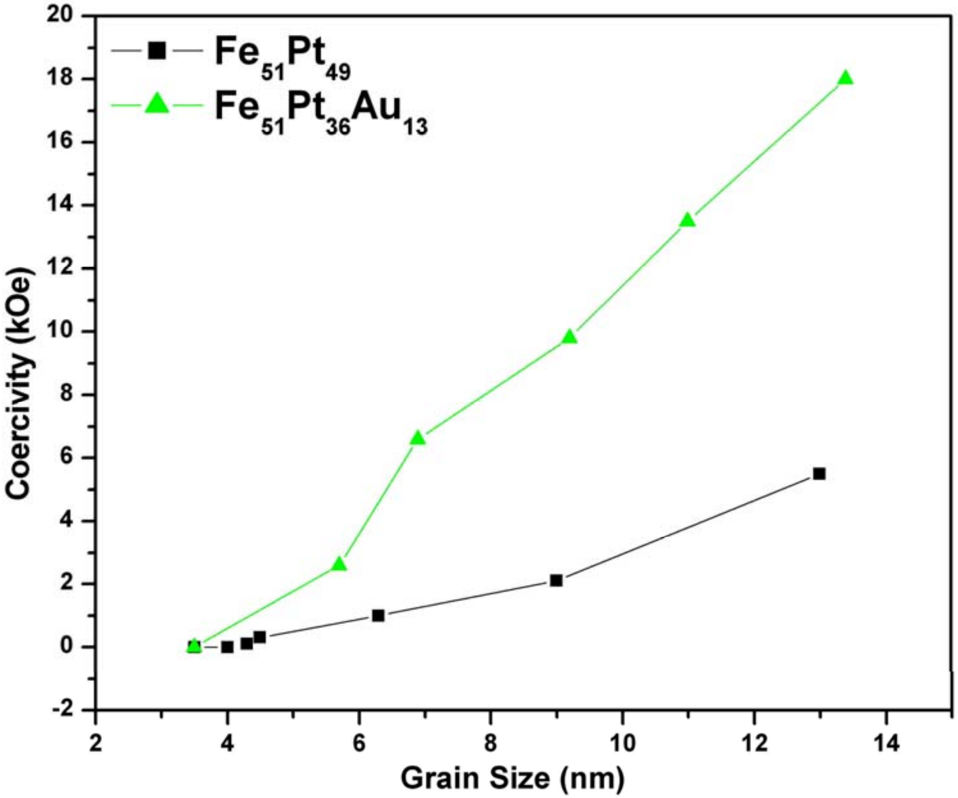
Correlation of Particle Size and Coercivity



- The higher coercivity of $Fe_{51}Pt_{36}Au_{13}$ particles for similar grain size indicates that the decrease in ordering temperature in $Fe_{51}Pt_{36}Au_{13}$ nanoparticles was primarily due to the Au doping, even though Au promoted the particles sintering.

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Conclusions

- $Fe_xPt_yAu_{100-x-y}$ nanoparticles with controlled composition were prepared.
- Decrease in the fcc to $L1_0$ transition temperature was found by more than 200˚C.
- The highest coercivity of 18 kOe with saturation magnetization 47 emu/g were obtained from $Fe_{51}Pt_{36}Au_{13}$ nanoparticles which suggests that for a particular composition of $Fe_xPt_yAu_{100-x-y}$ nanoparticles, the coercivity can be enhanced without almost any sacrifice in saturation magnetization.
- The higher coercivity of $Fe_{51}Pt_{36}Au_{13}$ than $Fe_{51}Pt_{49}$ particles for similar grain size implies that the increase in coercivity was primarily due to Au doping.

Acknowledgement

Department of Physics

Characterization Center of Nanomaterials and Biology

The University of Texas at Arlington

Dr. Chaun-bing Rong

Narayan Poudyal

Thank you

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