ESRF	**Experiment title:** **SEGREGATION AND ORDERING IN COVERED CO-PT MAGNETIC NANOPARTICLES**	**Experiment number**: HS-3080
Beamline: BM30B	**Date of experiment**: from: 12 April 2006 to: 18 April 2006	**Date of report**: 18/12/07
Shifts: 18	**Local contact(s)**: Dr. Vivian NASSIF	*Received at ESRF:*

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Aim and experimental method:

With respect to bulk materials, surface-supported nanoparticles offer additional degrees of freedom to tune the magnetic properties by controlled modifications of particle size, shape and interactions with the substrate. These characteristics make Co or Fe nanosized systems attractive for fundamental studies as well as for miniaturized data-storage applications. The key role property is the magnetic anisotropy energy, which describes the tendency of the magnetization to align along specific directions rather than randomly fluctuate over time.

The CoPt system maximizes the magnetic anisotropy energy of the Co 3d ferromagnetic phase, owing the strong spin-orbit coupling of Pt 5d states. Two kind of strategy can lead to a enhancement of the magnetic anisotropy: the formation of anisotropic $L1_0$ tetragonal nanoparticles and the core-shell Co-Pt nanoparticles. For the compositions near 50-50, a face centered cubic (FCC) disordered phase and a face centered tetragonal (FCT) Ll_0 ordered phase could be obtained. This latter structure can be described as alternate cobalt and platinum (001) planes, giving rise to a magnetocrystalline anisotropy along the (001) axis. The problem as in the case of core-shell particles is the stability of different Co-Pt phases after or during their preparation, due to the strong surface effect but certainly dependent on the particle size.

The preparation technique allows a great versatility regarding the morphology and atomic arrangement, and the possibility to protect without oxidation with a capping layer of Al_2O_3. Nanoclusters of different diameters (between 2 and 10nm) having different Co-Pt atomic arrangements: disordered, ordered (codeposition) or core-Pt shell-Co (sequential deposition) particles will be studied by means extended x-ray absorption fine structure (EXAFS) and complementarily, x-ray magnetic circular dichroism (XMCD) to correlate their structures with their magnetic properties. The aim is to reveal the effective coordination effect with respect to a structural anisotropy effect on the magnetism from Ll_0 ordered samples to core/shell nanoparticle assemblage respectively.

We have performed a XAFS spectrum in fluorescence detection at each edge of Co atoms (Co-K edge - 7709eV) and Pt atoms (Pt-L3 edge 11564 eV) at low temperature for each sample.

Results:

Samples: three pertinent samples are presented in this report: For the successive deposition relating to deposition of Pt atoms follow by deposition of Co atoms, the goal was to construct an artificial core (Pt)-shell (Co) structure. For codeposition sample we expect the two metals are alloyed in the crystallographic A1 cubique structure. Thus, the annealing experiment was performed in order to induce a structural

transformation toward the crystallographic L10 tetragonal structure that has quite interesting magnetic properties.

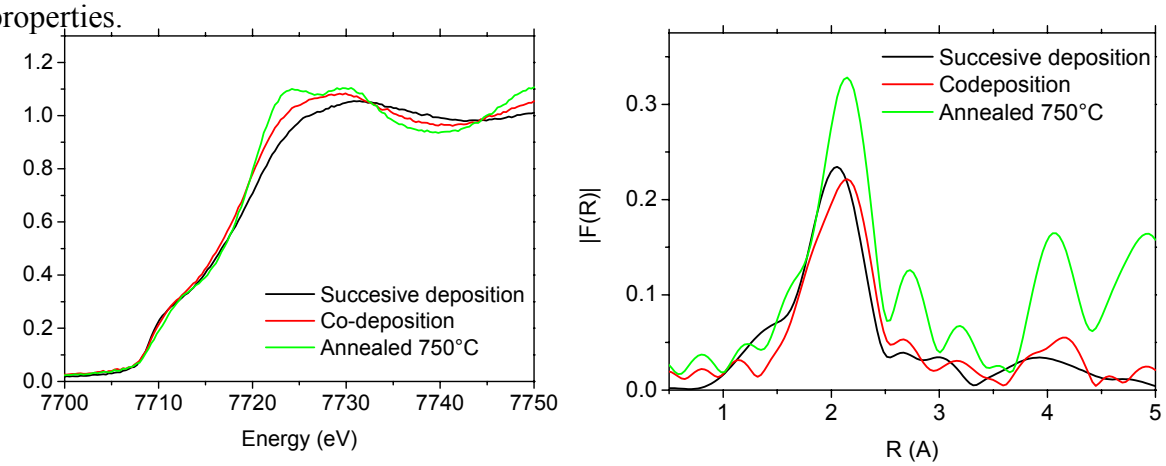

Figure 1: (a) XANES spectra and (b) Fourier Transform of the EXAFS spectra of different samples of CoPt nanoparticles at the Co K edge.

From the XANES spectra (figure 1.a) it appears that the three samples have different atomic and electronic structures. The annealed sample is quite interesting because of a particular double resonance above the edge [2]. The Fourier transform of the EXAFS spectrum allow obtaining the radial distribution (figure 1.b), in this figure we observe that the annealed sample have a second neighbours ordering because of good crystallographic organization induced by post annealing. The sample prepared by successive deposition have a contraction of Co-Metal interatomic distance that could be related to preferential Co-Co bonding or surface contraction effect due to the Co shell compared to the mixed sample (figure 1.b). Ab-intio calculation and fitting were performed with ATHENA and ARTEMIS software in order to obtain quantitative data from our experimental measurements. For sample prepared at room temperature the results shows the nanoparticles are well mixed without segregation effect, no trace of oxidation was detected proving the Al_2O_3 capping layer is efficient. For annealed sample we follow the Sinfelt method [3] in order to determine with accuracy structural parameters. The results (at Co and Pt edge) show unambiguously formation of the chemically ordered $L1_0$ structure as shown in table 1.

Edge	Path	N (exp)	N (A1)	N ($L1_0$)	Rexp (Å)	σ^2 (Å^2)	ΔE (eV)
Co	Co-Co	3.8	5.2	3.4	2.62	5.3×10^{-3}	-5.0
	Co-Pt	6.5	5.2	6.9	2.64	3.6×10^{-3}	-5.0
Pt	Pt-Co	6.9	5.4	7.2	2.64	8.3×10^{-3}	6.7
	Pt-Pt	3.9	5.4	3.6	2.69	0.6×10^{-3}	6.7

Table 1: Fit parameter for annealed sample, N(exp) relates to the number of neighbour, A1 and $L1_0$ show theoretical results.

This structural transformation from chemically disordered to chemically ordered structure has been confirmed by ex-situ HRTEM measurements [4]. Moreover our results show the sample prepared by successive deposition of Pt then Co have core (Pt)-shell (Co) structure. It proves that successive deposition of two metals is en efficient way to construct artificial Core Shell structure which could be linked to controlled magnetic properties.

The planned simultaneous EXAFS and (XMCD- BESSY-Berlin) experiments have given valuable information about the local magnetic and structural properties in the neighbourhood of the absorbing atoms. These combined results are in progress to be published.

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