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| ESRF | Experiment title:<br>**XMCD study of the inhibition of Co magnetism in W-capped Co nanoparticles** | Experiment number:<br>HE-2541 |
| Beamline:<br>ID12 | Date of experiment:<br>from: 30 January 2008 to: 05 February 2008 | Date of report:<br>6 April 2009 |
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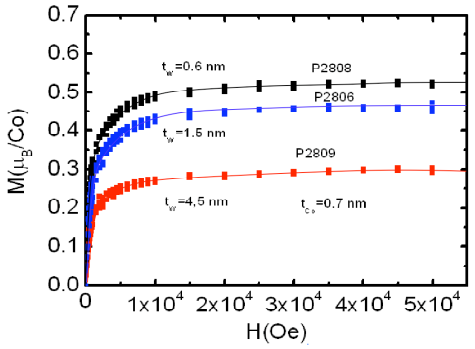
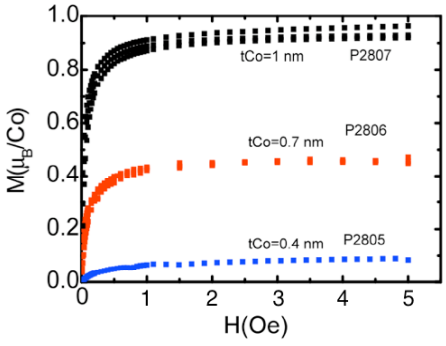
During the last years, we have studied the effects of capping the Co particles with a layer of a noble metal (Cu, Ag, Au) on the anisotropy of granular Co samples with the same size distribution. In HE-2541 we proposed to investigate Pt- and W-capped Co particles. Pt and W, having an unfilled 5d band could be expected to be more susceptible to be polarized, and the effects on the magnetism could be expected to be larger. Moreover, Pt and W are known to form alloys with Co. Although XMCD data measured at the $L_{2,3}$ edges of Pt (HE-1880 and HE-2081) and W (partially HE-2238), do show polarization of Pt and W, the magnetism of the system appears to be dominated not by hibridization, but by Co-Pt and Co-W alloying. The experiment HE-2541 is a continuation of HE-2238 in which we studied Ag- and W-capped particles. We proposed to measure XMCD at the L2,3-W and K-Co edges in two W thickness ($t_W$=0.6, 4.5 nm) for $t_{Co}$ = 0.7 nm and other two Co particle sizes ($t_{Co}$=0.4, 1 nm) for $t_W$ = 1.5 nm.

When preparing HE.2541 we had measured the bulk magnetisation of several CoW samples: the results and nominal thickness are shown in the figures and table below:




| $t_W$ (nm) \ $t_{Co}$ | 0.4 | 0.7 | 1 |
|---|---|---|---|
| 0.6 | | P2808 | |
| 1.5 | P2805 | P2806 | P2807 |
| 4.5 | | P2809 | |

*Fig 1: Magnetization for Co/W/$Al_2O_3$ granular multilayers for constant Co (left) and W (right) thickness. Table: labels of samples with the nominal thicnesses of Co and W.*

P2807 is the sample showing a larger net magnetic moment, and the XMCD signal at the $L_{2,3}$-W and K-Co edges could be measured very properly, although it actually took about **24h** to satisfactorily record the three edges.

The original experimental plan was modified and we did not measured XMCD at the W-$L_{2,3}$ edges at the P2805 sample, as it would had taken the whole allocated beamtime. We concentrated on P2808, P2809 and P2807 (P2806 was measured during HE-2238). We obtained the XMCD spectra with reasonable statistics at the $L_{2,3}$-W and K-Co edges of those three samples.

The experimental results in P2807 are shown in Figure 2. The integrals of the XMCD are also shown to evidence that the sum rules, although with relatively large incertitudes, can be applied to W in this system. Our result appear to confirm the parallel allignement between $\mu_L^W$ and $\mu_S^W$ as found by F. Wilhelm et al., in Fe-W layered system.

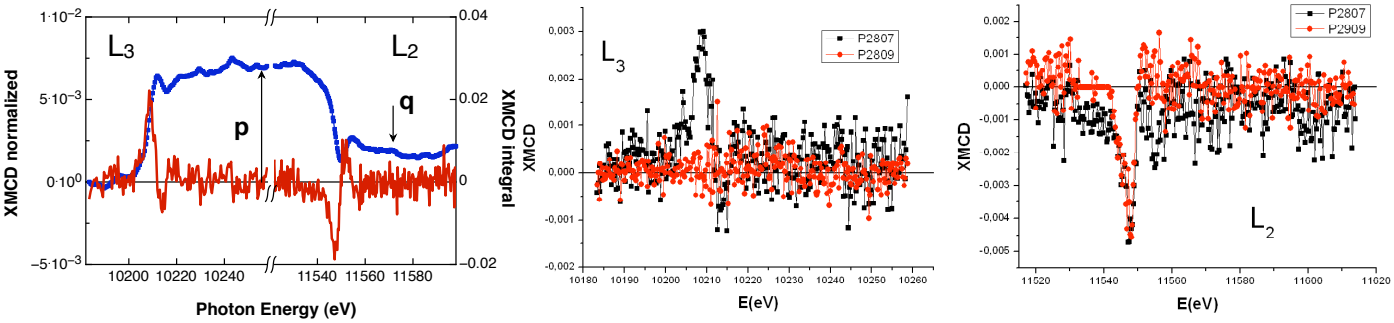



*Figure 2: XMCD measured at the L2,3 edges of W in P2807 (left). Comparison between L3 (center) and L2 (right) XMCD measured in P2807 and P2809 samples.*

The central and right panels of Fig. 2 shows clearly that depending on the size of the W capping layer, the orbital to spin ratio in W changes dramatically. While the L2 edge XMCD remains mostly unchanged, while L3 has been dramatically reduced, therefore indicating that change in the (net) Co magnetic moment has induced big changes in the spin-orbit coupling in W.

In the proposal we also asked ourselves whether the decreasing of the magnetic moment of the samples is originated by an homogeneous decrease of the Co moment per atom, or by the formation of the magnetically death shell in the particles, or by ferrimagnetic polarisation of the W polarized layer. It clearly appears that the W polarization os by far not enough to opposite so strongly to Co. The common treatment and Co-K edge in P2808 and P2806.

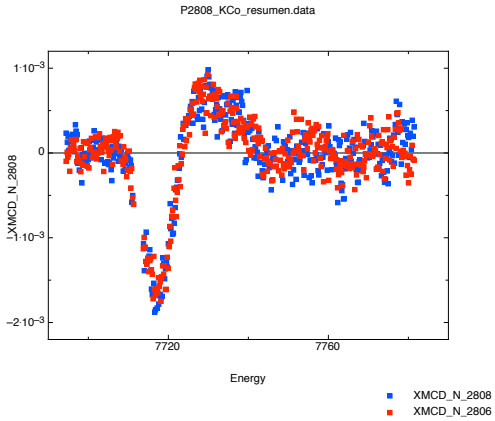



*Figure 3: raw XMCD measured at the L3 (left) and L2 (right) edges of W in P2807 and (left) and Co-K edge in P2808 and P2806.*

From the EXAFS results obtained in HE-2952 in Co and W edges we find evidence of a reduced Co coordination upon W capping, suggesting a reduction in the Cobalt core size. This result tends to the creation of a magnetic dead shell around the Co-NPs proposed after magnetic measurements on these systems. Apparently, the magnetic moment per atom of the magnetic Co core may not be strongly affected, but the total number of ferromagnetic Co atoms is very much reduced by alloying.

References: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