MAGNETIC PROPERTIES OF Co NANOPARTICLES CAPPED WITH A W THIN FILM

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Co nanoparticles are formed by sputtering of Co on amorphous alumina substrate. A subsequent capping of the particles with a metal film creates a matrix which surrounds the particles. The Co mean diameter prior to capping depends on the nominal thickness t_{Co} of the deposited Co. When capping with a noble metal film of nominal width t_M, like Cu, Ag or Au, i.e. with the nd band nearly fully occupied, the particles behave as superparamagnet with an anisotropy constant that depends on the metal used [1]. The average diameter of the nanoparticle modifies strongly the magnetic behavior, because of the relative increase of the number of atoms at the surface with respect to the core, while the width of the noble metal capping plays no role.

In this work the capping metal is W, which has less than half filled $5d^4$ band, which gives rise to completely different trends in the dependence of their magnetic properties with the configuration of the multilayers. We present results on samples with t_{Co}=0.4, 0.7 and 1 nm, with a capping film of t_W= 0.6, 1.5 and 4.5 nm, and the number of layers ranging between N=20 and 25 (Fig. 1 and 2). Magnetization and susceptibility measurements and XMCD spectroscopy experiments were performed to study their magnetic properties. All the measured samples showed superparamagnetic behavior above a blocking temperature T_B which increases with t_{Co}, just as with the noble metal capping. However, in stark contrast with them, the saturation magnetization per atom decreases strongly with decreasing t_{Co}, and it also decreases with increasing width of the capping W below T_B. These results are consistent with the formation of a magnetic dead shell around the Co core of the nanocluster, of CoW alloys (Fig. 3). The amount of W and the effective surface of the particle surface modulate the thickness of the dead shell, thereby, modifying the mean Co moment and particle anisotropy.

XMCD measurements performed at the W $L_{2,3}$ edges (Fig. 4) reveal a polarization of $\sim 10^{-2}\mu_B$ at W moments antiparallel coupled to Co moments. Application of sum's rules to XMCD data allows us to identify a parallel arrangement of the W orbital and spin moments which implies a Hund's third rule violation as it has been previously observed in Fe/W multilayers [2].

References:

[1] F. Luis, F. Bartolomé, F. Petroff, J. Bartolomé, L.M. García, C. Deranlot, H. Jaffres, M.J. Martinez, P. Bencock, F. Wilhelm, A. Rogalev and N.B. Brookes. Europhys. Lett. **76**, 1 (2006) 142-148.

[2] F. Wilhelm, P. Poulopoulos, H. Wende, A. Scherz, K. Baberschke, M. Angelakeris N. K. Flevaris and A. Rogalev. PRL **87**, 20 (2001) 207202.

Figures:

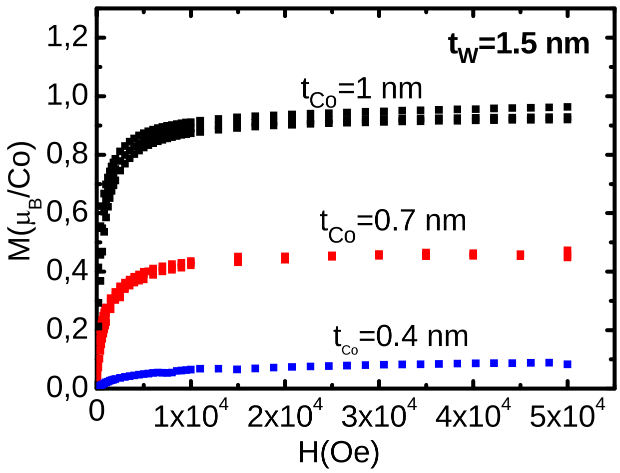

Fig 1. Magnetization curves for samples with t_{Co}=0.4, 0.7 and 1.0 nm, and a capping film of t_W=1.5nm, showing how the saturation magnetization per atom decreases with decreasing t_{Co}.

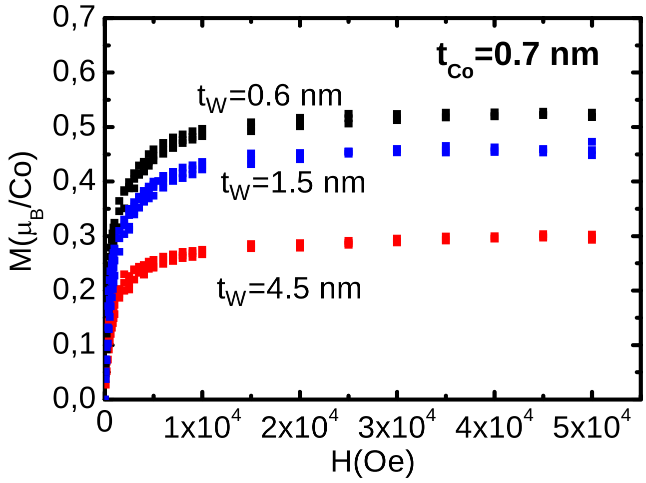

Fig 2. Magnetization curves for samples with t_{Co}=0.7 nm, and different W capping width, t_W= 0.6, 1.5 and 4.5 nm, showing how the saturation magnetization per atom decreases with increasing width of the capping W below T_B.

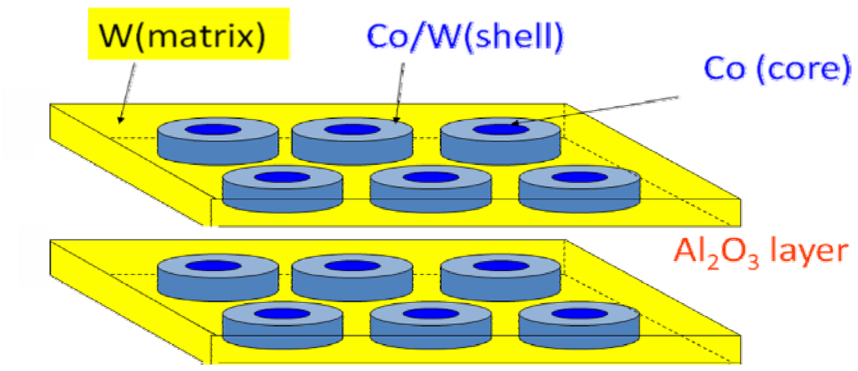

Fig 3. Diagram of the possible formation of a magnetic dead shell (of Co_3W alloy) around the Co core.

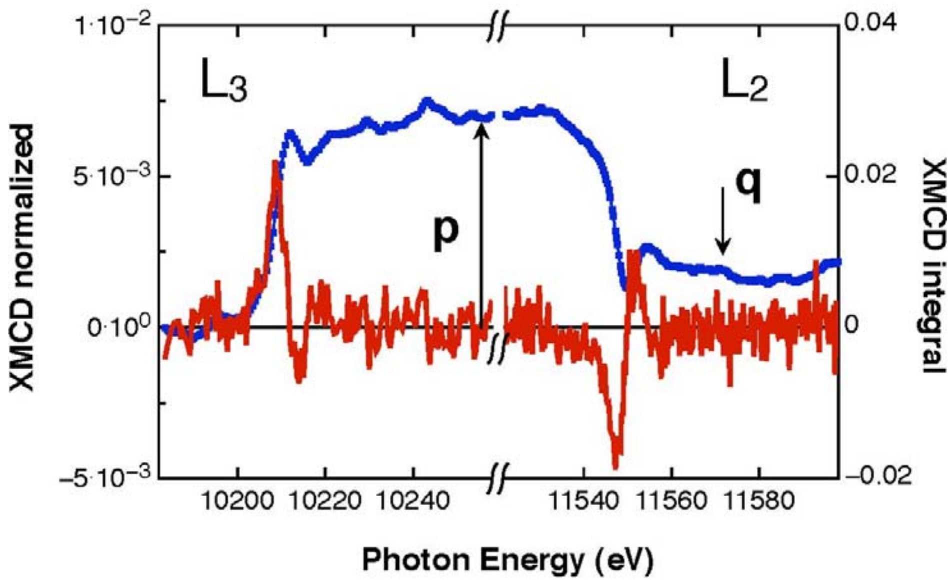

Fig 4. Normalized XMCD spectra (left) and XMCD integrated area (right) at the W $L_{2,3}$ edges in a sample with t_{Co}= 1.0 nm, and a capping film of t_W=1.5nm.