Experiment report

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Symmetry selective Spin Polarization of Ag in 3D nanostructured Systems with Giant Magneto resistance

The aim of this work was to investigate the spin polarization of silver induced by the contact with 3d magnetic particles of cobalt. The XMCD data at silver L_2-L_3 edges were collected for three samples at BL6 at the ESRF. The role played by the geometry of the environment i.e; the surface/volume ratio tuned by the size and the shape of the magnetic particles is an essential point. 2D-like samples where particles are pancake-shaped embedded with a good periodicity in a quasi multilayer have been compared to 3D-nanostructured samples with cobalt clusters randomly distributed in a silver matrix with a cluster concentration kept less than the percolation limit.

These experiments were ESRF-specific for two reasons. First, the energy range of the L_2-L_3 edges(3524, 3351eV) is not currently accessible at most of the national synchrotrons facilities. Second, the use of fluorescence detection scheme is compulsory because of the presence of thick substrate together with very thin samples (typically 500 Å). The outstanding detection scheme, at BL 6 relies on the unique silicon detectors developed at ESRF by C. Gautier and J.Goulon. It allows to collect the fluorescent photons over a wide solid angle with a good efficiency and excellent energy resolution even operated at room temperature.
Since it was not yet possible to switch the direction of the applied magnetic field to obtain a XMCD signal, we proceed by phasing of the helical undulator to switch the helicity of the photons Although this procedure was challenging for low signals a very good XMCD signal to noise ratio of a few tens after only two scans for a signal which turns out to be a few 10^{-3}.
We measured three different samples. The first was a $(Ag\ 7.5Å/Co\ 20Å)_{240}$ multilayer, the second sample, a multi layer with thinner layers $(Ag\ 5Å/Co\ 4Å)_{360}$ where most of the atoms are located at the interfaces. The last sample consists of nanoclusters of Co in a Ag matrix. The amount of Co cluster is 25% of the total volume which is just below the percolation limit.

- The Ag-XMCD signal of the $(Ag\ 7.5Å/Co\ 20Å)240$ multilayer, shows a positive peak at the L_3 edge of -3.5.10-3 ±0.5 10-3 and a negative peak at the L_2 edge of +12.5 $10^{-3} \pm 10^{-3}$ once normalized by the relevant edge absorption jumps.

As proven by Sham et al by transmission measurements the ratio of the total absorption cross-section L_3/L_2 is 2. Therefore, using the constant normalisation at the L_3 edge, these two values turn out to be -3.5 $10^{-3} \pm 0.5\ 10^{-3}$ and $+6.25\ 10^{-3} \pm 0.5\ 10^{-3}$. In addition the rate of circular polarisation is energy dependent since it is controlled by the Bragg angle of the reflected photons selected by the monochromator which are estimated to be 26% and 40% respectively. Finally when normalized to 100% of circular polarization, the signals are: -14.10-3 ±2 10-3 and 16.10-3 ±1 10^{-3}.
These results evidence a dominant spin polarization of the 4d band of silver () induced by the spin polarisation of the cobalt 3d band and an orbital polarisation which is zero.

> *We assume that problems due to self-absorption processes in the fluoresence detection scheme play a minor role because of the very small thicknesses of our samples as experimentally checked with subsequent experiments at the Pd L-edges.*

- The XMCD signal of the (Ag 5 /Co 4)x360 is small at the L_3 edge (-8.10-3 ±2 10^{-3}, fully renormalized) and no significant signal has been detected at the L_2 edge. This results shows that the spin polarization of the silver is smaller in this case, but the orbital momentum is increased slightly emerging ($\approx 0.001\ \mu_B$).
- We did not detect any XMCD signal in the nanocluster compound.

These results show that the spin polarization of silver is mainly present in the first multilayer (Ag 7.5 /Co 20)x240, created by the fully magnetized thick cobalt layer which polarizes the atoms of silver at the interface. The sign of the XMCD signal is consistent with a parrallel coupling between silver and cobalt atoms.

The spin polarization of silver is greatly reduced in the second multilayer where the thicknesses of cobalt and silver are of 2 atomic layers and perhaps partly interdiffused. The cobalt polarisation is very likely decreased and therefore the silver spin polarisation of silver subsequently decreased. Nevertheless the trends of the orbital polarisation is not to follow the spin polarisation as expected if one thinks at the direct silver spin-orbit interaction to lead the mechanism of orbital polarisation of silver. Conversely the cobalt-induced polarisation of silver may work for both spin and orbital moment polarisations. The measurement of cobalt XMCD spectra at L-edges is crucial to go further in the interpretation of the present data.

In the last case, where the amount of silver atoms involved in cobalt/silver interfaces is too low, the spin polarization of silver is not detected.