XMaS the UK-CRG	**Experiment title:** **Nanostructures of Co/Ag granular systems**	**Experiment number**: 28-01-723
Beamline: **BM 28**	**Date of experiment**: from: 13/4/2005 to: 19/4/2005	**Date of report**: 28/10/2006
Shifts: 18	**Local contact(s)**: Laurence Bouchenoire	*Received at XMaS:*

Names and affiliations of applicants (* indicates experimentalists):

*José De Toro Department of Physics, University of Liverpool & Departamento de Fisica Aplicada, Universidad de Castilla-La Mancha

*Raymond Fan Department of Physics, University of Liverpool

*Simon Lee Department of Physics, University of Liverpool

*Jon Goff Department of Physics, University of Liverpool

Report:

A record 40% room temperature giant magnetoresistance (GMR) was observed in a nanogranular Co/Ag alloy by optimizing the concentration, sputtering conditions and heat treatment. The dependence of the GMR on annealing conditions was complex, with a minimum at 230°C and a maximum at 300°C, see Fig. 1. Structural studies were performed using the XMaS UK-CRG at the ESRF, in an attempt to obtain a microscopic understanding of this unusual behaviour. High-angle scattering enables the matrix and nanoparticle lattices to be compared with the bulk, see Fig. 2, and small-angle scattering allows the nanoparticle size distribution to be determined, see Fig. 3.

The as-grown samples have Ag impurities in the Co nanoparticles, and Co solute in the Ag matrix. Upon annealing phase separation occurs and the nanoparticles grow slightly, increasing the dipolar interactions and leading to the minimum in GMR at 230°C. Further annealing leads to the removal of solute Co atoms from the matrix, suppressing the RKKY-like contribution to the interparticle interactions, and leading to the maximum in GMR at 300°C. Eventually, annealing leads to the agglomeration of nanoparticles, and the accompanying decrease in the interfacial area and the increase in the dipolar interactions suppresses the GMR.

Hence, we are able to understand the complicated, but highly desirable properties of a system that is easy to fabricate and, therefore, with potential for practical applications.

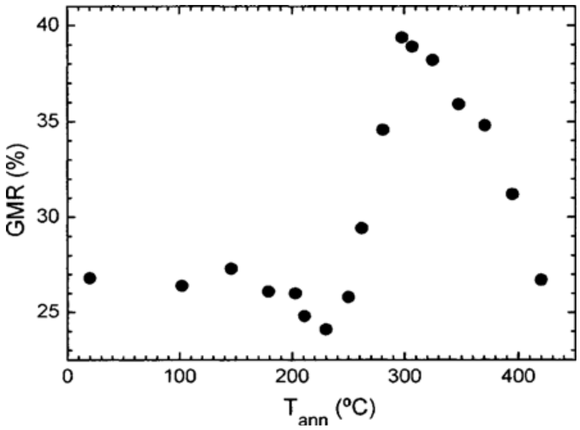
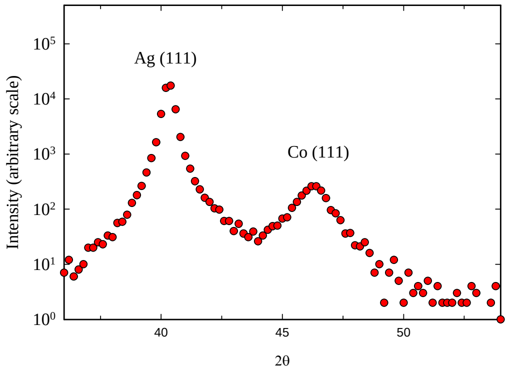


Fig. 1. The room-temperature giant magnetoresistance (GMR) from nanogranular cobalt in a silver matrix. The dependence on annealing temperature is complex, but a record 40% GMR is achieved with a simple heat treatment.

Fig. 2. The high-angle x-ray diffraction shows that the thin-film samples are textured with a [111] direction normal to the surface. The figure shows Bragg peaks from the Ag matrix and the Co nanogranules. The dependence of the lattice parameters on annealing temperature shows that phase separation occurs. This reduces the RKKY-like interactions, and is responsible for the peak in the GMR at 300°C.



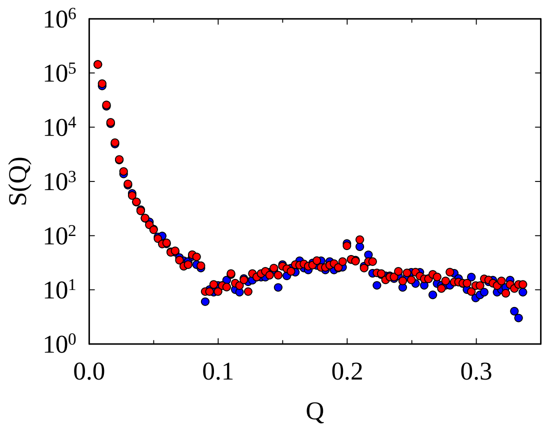


Fig. 3. The small-angle x-ray scattering (in conjunction with small-angle neutron scattering) allows the nanoparticle size distributions to be determined. We find that, at first, there is a small increase in particle size, and this is responsible for the dip in GMR at 230°C. There is then a substantial increase in particle size due to the agglomeration of particles at 420°C, and this causes the GMR to fall at high temperature.