XMaS the UK-CRG	**Experiment title:** **The interface structure of magnesium oxide magnetic tunnel junctions**	**Experiment number**: 28-01-850
Beamline: **BM 28**	**Date of experiment**: from: 10-DEC-08 to: 15-DEC-08	**Date of report**: 04th Nov 2009
Shifts: 18	**Local contact(s)**: L. Bouchenoire and S. Brown	*Received at XMaS:*

Names and affiliations of applicants (* indicates experimentalists):

T.P.A. Hase*,
Department of Physics, University of Warwick, Coventry CV4 7AL, U.K.

M. Vadala*, B. K. Tanner*
Department of Physics, University of Durham, Durham, DH1 3LE, U.K.

L. Bouchenoire*, S. Brown*
XMaS CRG, European Synchrotron Radiation Facility, Grenoble, France

Report:

We have continued our studies on understanding the growth in tunnel junctions (MTJ) with oxide barriers and metallic conductors. The magnetic properties of these systems are critically dependent on the interdiffusion at the electrode / insulator interface and we have studied this process in $[Co/MgO]_5$ and $[Co/Al_2O_3]_5$ multilayers. It is now well established that the presence of interface roughness reduces the TMR ratio in MTJs. Theoretical work has attributed the large difference between hypothesised and experimental TMR values to such interfacial disorder of which a significant contribution (20%) comes from the intermixing (or interdiffusion) at the interface. To date, we have concentrated our scattering experiments on elucidating the interface structure in $[Co/MgO]_5$ and $[Co/Al_2O_3]_5$ multilayers with and without pre-oxidization of the metallic electrode. The novel use of pre-oxidation of the metallic electrodes results in reduced interdiffusion at Co/Al_2O_3 interfaces leading to a reduced magnetic coupling between the layers and a lowering of the switching field.

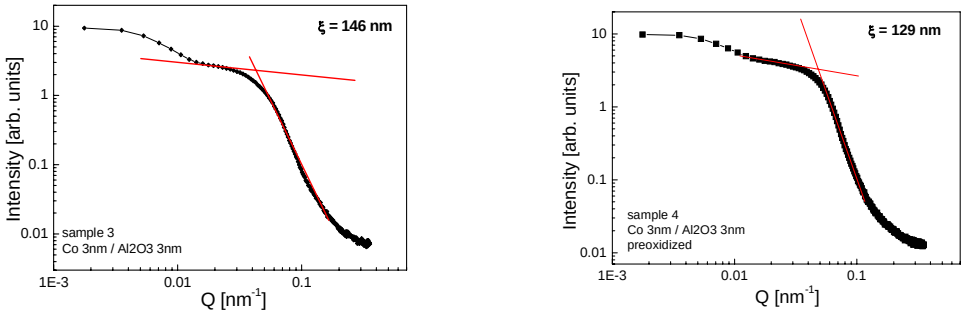

Figure 1. htth scans obtained for a [Co 3nm/Al_2O_3 3nm]$_5$ multilayer without preoxidation (left) and with preoxidation (right).

We have attempted to determine the in-plane correlation length for sample pairs (with and without pre-oxidization) by measuring the diffuse scatter as a function of in-plane momentum transfer orthogonal to the scattering plane. In Fig. 1 we compare two [Co 3nm/Al_2O_3 3nm]$_5$ multilayers produced with and without pre-oxidation. The cross-over points seen in fig. 1 correspond to a cut-off frequency in the roughness power spectrum for which the interface is self-scaling and gives the in-plane correlation length. We have determined correlation lengths of ξ = 0.130±0.01 μm and ξ = 0.150±0.01 μm for the sample with and without pre-oxidization. Analogous measurements on two [Co3nm/MgO3nm]$_5$ multilayers are plotted in Fig.2. In the graph of the Co/MgO preoxidized sample we observe a different q dependence of the diffuse scatter. Unlike the Co/Al_2O_3 samples and the un-oxidised sample we observe a second critical length scales. We do not yet have a clear explanation of this phenomenon, but the correlation length determined for the un-oxidised sample is ξ = 0.52±0.01 μm compared with only ξ = 0.12±0.01 μm with pre-oxidization. Detailed analyses of these data sets are on-going.

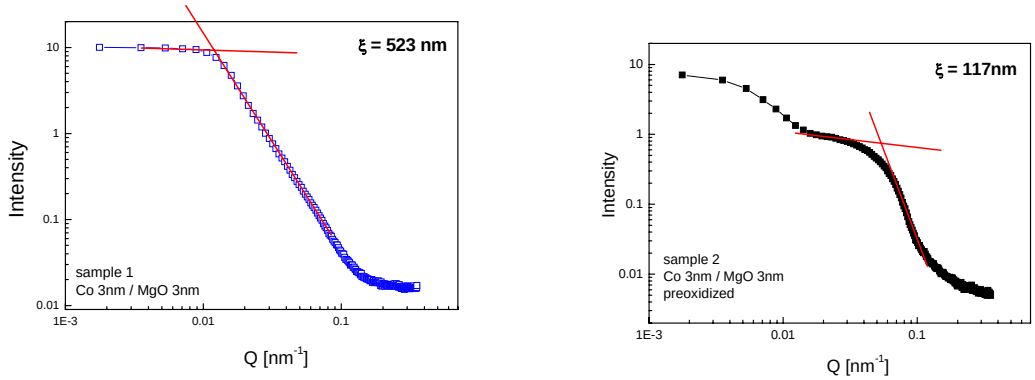

Figure 2. Out-of-plane 2θ (htth) scans obtained for a [Co 3nm/MgO 3nm]$_5$ multilayer without preoxidation (left) and with preoxidation (right).

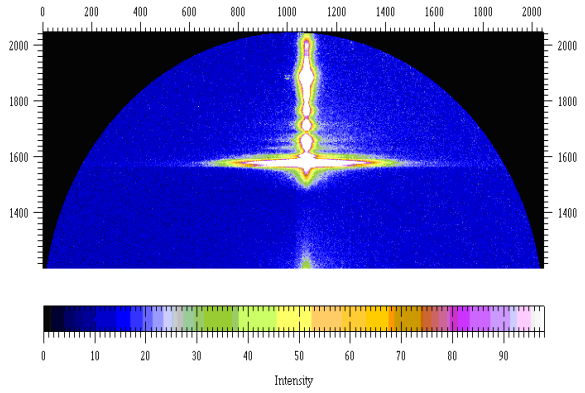

Figure 3. Full reciprocal space map of the diffuse scatter for sample 2, recorded at T=300K, showing the correlated nature of the roughness.

The interface morphology of the specimen was further investigated using the MAR CCD camera and mapping the diffuse data as a function of both q_z and q_y. In Fig.3 we display the full reciprocal space map of the diffuse scatter, recorded at T=300 K, for a representative multilayer. The common trend that we have observed for the samples with preoxidation is the presence of extended Bragg sheets, which are much less defined and sometimes missing in the samples without preoxidized. We have since performed similar experiments at the Diamond light source, beamline I16. We observed increased scatter for the samples without preoxidation the near edge critical region with comparable results for preoxidized samples. We are continuing to process the data and attribute structural changes with the observed changes in the magneto transport and anticipate a publication with our NIST collaborators in the near future.