ESRF	**Experiment title:** Grazing incidence X-ray diffuse scattering from interfaces in transition metal magnetic multi-layers	**Experiment number:** HC-576
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Shifts:	**Local contact(s):** Gavin Vaughan	*Received at ESRF :* 0 8 JAN 1997

Names and affiliations of applicants (*indicates experimentalists):

Professor B.K. Tanner*, University of Durham

Dr. I. Pape*, University of Durham

Mr. T.P.A. Hase*, University of Durham

Report:

The primary aim of this experiment was to undertake grazing incidence diffuse X-ray scattering measurements on Co-Cu multilayers which show giant magnetoresistance (GMR). This forms part of a wider investigation into the role of interface roughness and crystallographic texture on the magnitude of the GMR. Our diffuse scatter data are fitted to a fractal model of the surface and interfaces and our objective was to use the intensity and short wavelength of the ESRF to make measurements much further out in reciprocal space than is possible at the Daresbury Laboratory SRS.

Due to the delay in the commissioning of beamline BM16, our beamtime was postponed by an allocation period, and in the intervening time we were able to confirm the tentative assertion in our proposal that the fractal dimension of our MBE grown samples was significantly different from our sputtered samples [1]. In order to confirm the fractal dimension independently of the correlation length we performed radial scans in reciprocal space (offset θ-2θ scans) out to very high values of scattering vector q_z. From the gradient of these scans, we attempted to determine the value of the fractal parameter h. In April 1995, we performed test experiments on the Swiss-Norwegian beamline which indicated that the high values of q_z needed were attainable with sufficient signal to noise on beamline BM16. Unfortunately, our experience was that the expected scaling from the Swiss-

Norwegian beamline to beamline BM16 did not occur, and we conclude that the monochromator/mirror assembly there is not yet performing up to specification.

Nevertheless, we successfully performed the fist grazing incidence reflectivity and scattering measurements on beamline BM16 using the experimental procedures developed at the Daresbury SRS and the Swiss-Norwegian beamline. Despite the disappointment, the data quality was significantly better than achieved at the SRS, although we were unable to tune the monochromator to long enough wavelength to access the Cu absorption edge for anomalous scattering experiments. Test experiments on the glass ceramic Zerodur showed that logarithmic scaling of the intensity occurred as predicted and the value of the fractal parameter deduced was in very good agreement with that deduced from transverse scans in reciprocal space [2]. However, for very high values of q_z the gradient changed to a value independent of the sample. We believe this scattering to be from the monochromator system and its presence made the interpretation of the data from the multilayers extremely difficult. Logarithmic scaling was observed but the presence of conformal roughness resulted in peak in the data corresponding to Bragg reflections from the multilayer. These peaks were superimposed on the logarithmic intensity variation. At low values of q_z, the gradient led to a reasonable fractal parameter value, but here the approximations in the theory are not properly satisfied. At high q_z values, the gradient decreased, tending towards the sample-independent value noted above. Although we verified that logarithmic scaling of the intensity was observed in all the metallic multilayer samples we examined, having now analysed the data carefully, we cannot (for this system) place strong reliance on the fractal dimensions deduced.

We also undertook diffuse scattering experiments around the 111 reciprocal lattice point using the triple axis geometry. We performed measurements with both a slit and an analyser crystal before the detector. Of particular concern was the variation of the q_y width of the zero order and the first order satellite peak from the Co-Cu multilayer in a series of samples grown at different temperatures and in which both the GMR and the conformal interface roughness varied systematically. Using a wavelength of 0.6Å at the ESRF compared with 1.38Å at the SRS, we were able to show that the widths were independent of q, being the same on an angular scale in real space. A single Lorentzian gave a good fit to the peak shape for all samples. This proves that the broadening is due to tilts, not interface roughness, and is a measure of the mosaicity of the samples. There is a strong correlation between the full width at half height maximum of these rocking curves and the GMR. While the error bars are less for the zero order than the first order satellite peaks, for any one sample there is no systematic difference between the widths. All data can be incorporated on a single plot of FWHM versus GMR. The importance of this result is to show that **both** the interface roughness and the crystallographic texture vary systematically with the GMR. It will take further measurements to discover the role of each in determining the magnitude of the GMR.

[1] B K Tanner, D E Joyce, T P A Hase, I Pape, and P J Grundy, Adv. X-ray Analysis 40 (1997) in press

[2] M Wormington, I Pape, T P A Hase, B K Tanner and D K Bowen, Phil Mag Letts 74 (1996) 211