ESRF	**Experiment title:** Interface Structure in Spin-Valve Systems	**Experiment number:** S1342
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Report:

Spin-valve devices based on the giant magnetoresistance (GMR) effect are about to go into production for computer disc read heads. For good performance it is is essential to control the thickness of the Cu spacer layer to monolayer precision and we have elsewhere shown how grazing incidence X-ray fluorescence can be used to perform this measurement non-destructively [1]. The inter-facial roughness in these devices appears also to be important in determining the magnitude of the GMR. We have attempted to use the tunability and high brilliance of the ESRF synchrotron source to probe the Co/Cu interface structure within in the spin-valve structure. The samples were composed of thin layers of Ta(45Å)/Permalloy(33-Å)/Co(3Å)/Cu(30Å)/Co(3Å)/Permalloy(33Å)/FeMn(75Å)/ta(45Å). Simulations indicated that by performing grazing incidence scattering measuremnts at and away from the Cu absorption edge we could selectively enhance the scattering from the Cu/Co interface and hence determine the roughness.

There is considerable interest in the integration of spin valves into silicon planar devices and the first such sensors are now on the market. These devices are grown on low temperature ‘native’ oxide on Si which is relatively rough. We have compared spin-valves deposited on two oxide surfaces, one grown thermally and the other deposition-oxidised.

Results:

A series of grazing incidence reflectivity scans were performed for each sample at two wavelengths, 1.381Å and 1.48Å. Specular ($\theta/2\theta$), off-specular ($\theta+\delta/2\theta$) and transverse diffuse scans were carried out to allow a complete characterization of each sample. Studies of the two bare (native oxide) substrates showed that the thermal oxide had a very smooth surface (r.m.s roughness ~2Å) whilst the deposition-oxidised surface was very rough (r.m.s roughness ~17Å), which is consistent with the tiled surface shown in AFM measurements. The fall-off in intensity for the specular reflectivity from the spin valves is similar in form to that of the oxide substrates. Since with every sample the specular intensity had dropped to around zero by a scattering angle of about 6° we were unable to probe high enough q_z to use the anomalous dispersion to highlight the Co/Cu interface as intended. Only by preparation of samples with significantly lower roughness may this be possible.

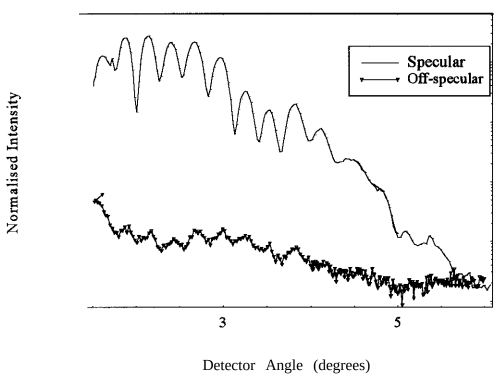

Figure 1

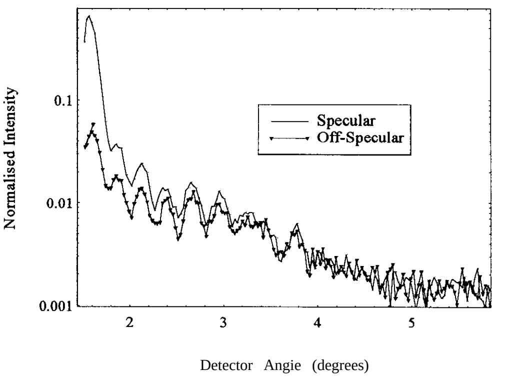

Figure 2

It was observed that **all** the spin-valves grown on these substrates have remarkably strong out-of-plane correlation in the roughness. This is deduced from the prominence of the Kiessig fringes in the off-specular scatter. Figures 1 and 2 show examples of the specular and off-specular scatter from identical spin-valve structures deposited on the thermal and deposition oxide substrates respectively. The top surface roughness is nearly equal to the roughness of the substrates and it is implausible to postulate a mechanism of roughness propagation which does not retain that degree of correlation at the buried interfaces. Thus we deduce, albeit indirectly, that the Co/Cu interface roughness is comparable with that of the top surface. Spin valves integrated onto deposition-oxidised silicon surfaces thus will have a very rough Co/Cu interface and may explain the lower magnetoresistance observed.

[l] T. P. A. Hase, B. K. Tanner, P. Ryan, C. H. Marrows and B. J. Hickey, I. E. E. E. Trans. Magnetics 34 (1998) 83 l-3