ESRF	**Experiment title:** X-ray Magnetic Diffuse Scattering from Gd/W Multilayers	**Experiment number**: 28-01-605
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Report:

Layered materials containing magnetic ultrathin layers have paved the way for increased computing power. Spin valves, advanced layered materials, are now a major component of hard drive read heads in new computers. Since the interfaces in these materials are never perfectly flat there is interest in how the performance of these devices is affected by roughness. Many studies of roughness concentrate on the structure of the two materials at the interface. In magnetic layered materials, such as spin valves or magnetic multilayers, there is also magnetic roughness. Structural roughness can be quantified by some measure of the presence or absence of a particular material at an interface. In contrast to this magnetic roughness is a vector quantity. This coupled with the long range exchange interaction between magnetic moments means that the two quantities, i.e. magnetic and structural roughness will be different (for examples see references 1 and 2).

The aim of the experiment was to measure the scattering from a roughened Gd/W multilayer and use the result to quantify the magnetic roughness. A hypothetical multilayer with perfectly flat interfaces will give rise to specular scattering where the width in the specular ridge is due to the resolution of the instrument. Rough interfaces will cause diffuse scattering around the specular position. A sharp resolution limited peak that occurs at the specular position is due to the coherence length of the beam. A measure of this diffuse scattering will yield a correlation function $C(r)$ which gives the probability of two quantities a distance r apart at the interface being equal.[3]

The multilayers were prepared using dc magnetron sputtering. Multilayers fabricated in this way exhibit very little roughness. In order to produce the roughness the Si(001) templates were predeposited with 50nm Cu grown by molecular beam epitaxy (MBE) with the substrate held at 500º. The specular scattering from the multilayer is shown in Fig. 1. This multilayer exhibits significant diffuse scattering as can be seen in Fig. 2. This scattering is the result of rocking the sample through the specular position at the first multilayer Bragg peak.

This diffuse scattering is the result of the charge scattering and therefore only gives information on the structural roughness. In order to pick out the magnetic diffuse scattering we used circularly polarised X-rays tuned to the L_3 resonance edge of Gd. This was achieved with a diamond phase plate which achieved 96.4% circular polarisation. The sample was held in a near horizontal plane. In order to satisfy the selection rules the magnetic field was applied in both the sample plane and the plane of incidence. The dichroism was measured by taking the difference between the intensities when the magnetic field was applied parallel and antiparallel to the direction of the beam. Shown in Fig. 2 is also the difference i.e. the dichroism in the diffuse scatter. The small difference between the two plots, which have been scaled for clarity, is significant (error bars are much smaller than the symbols). Although analysis is ongoing we can conclude that the interfaces are magnetically smoother than they are structurally. The challenge in the detailed analysis is to find the magnetic-magnetic correlation function. This is not so simple since the magnetic diffuse scattering cross-section consists of a term which depends on the structural-magnetic correlations.[4]

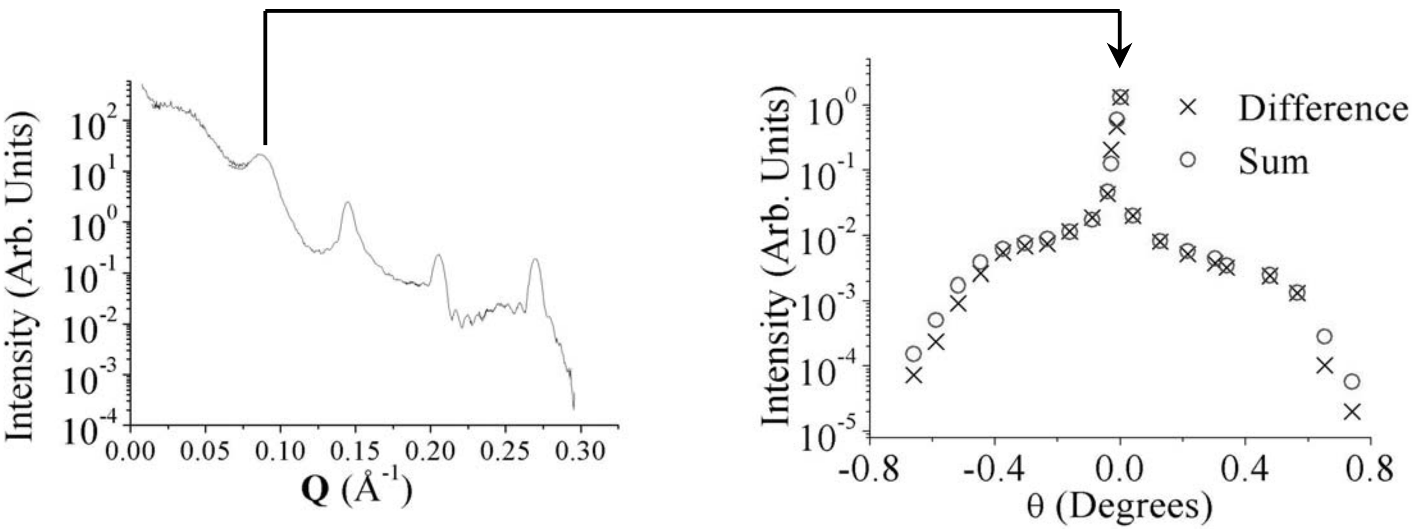

Fig. 1. The specular reflectivity from the multilayer.

Fig. 2. The diffuse scattering at the first order multilayer Bragg peak. Shown is the difference signal, i.e. the circular dichroism, and the sum, i.e. the charge scattering. The error bars in the diffuse scattering are smaller than the symbols. The two plots have been scaled for clarity.

References

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