XMaS the UK-CRG	**Experiment title:** **Structural and magnetic properties of Fe/Mn superlattices**	**Experiment number**: 28-01-611
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Report:

The phase of Mn stable at room temperature, α-Mn, has an unusually complex crystal structure, and its magnetic structure has not been solved. However, much simpler cubic structures are stable at elevated temperature, and using molecular beam epitaxy these may be stabilized at low temperatures [1], allowing the magnetic ordering to be studied. The first neutron diffraction study of the magnetic ordering in exchange-coupled Fe/Mn superlattices produced some novel and unexpected results [2]. A single-crystal superlattice of composition $[Fe_9/Mn_4]_{300}$ was found to adopt the BCT structure. The results from this superlattice with only four atomic planes of Mn in each bilayer allow us to focus on the interfacial region. The ferromagnetic Fe blocks were found to couple antiferromagnetically across the paramagnetic Mn layers at room temperature, and the Mn ordered with a simple antiferromagnetic structure below T_N ~ 187 K. Theory predicts either an antiferromagnetic structure with the moments in the same direction as those of the Fe, or a helical structure [3]. Surprisingly, we found that the moments in the Mn are perpendicular to those of the Fe, see Fig. 1. The interactions between antiferromagnetic and ferromagnetic blocks are of great technological interest since they are responsible for exchange biasing in GMR spin valves and tunnel junctions [4].

The aim of this experiment was to determine the detailed structure at the interfaces using the superlattice diffraction harmonics. Figure 2 shows a typical fit of the structural model to the XMaS data. By measuring the harmonics with x-ray energies near to the Mn K-edge it was possible to vary the anomalous dispersion and, therefore, the scattering contrast between the Mn and the Fe. In this way it was possible to obtain a unique solution to the structural model. We find that the interface comprises terraces with steps of approximately one atomic plane. It therefore seems likely that the magnetic structure observed in Fig. 1 arises as a consequence of the frustration at steps in the interfaces.

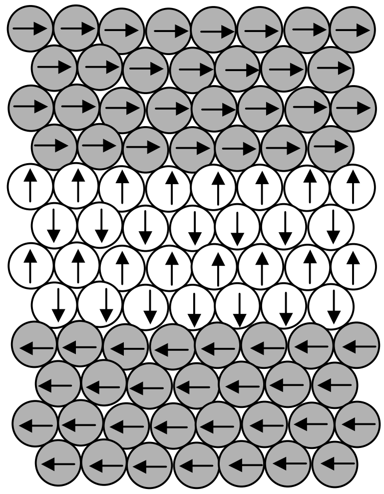

Fig. 1. Schematic diagram of the proposed magnetic structure for the superlattice of composition $[Fe_9Mn_4]_{300}$. The absence of neutron magnetic reflections from Mn along $\boldsymbol{Q}$=[00L] indicates that the Mn moments point along the growth direction.

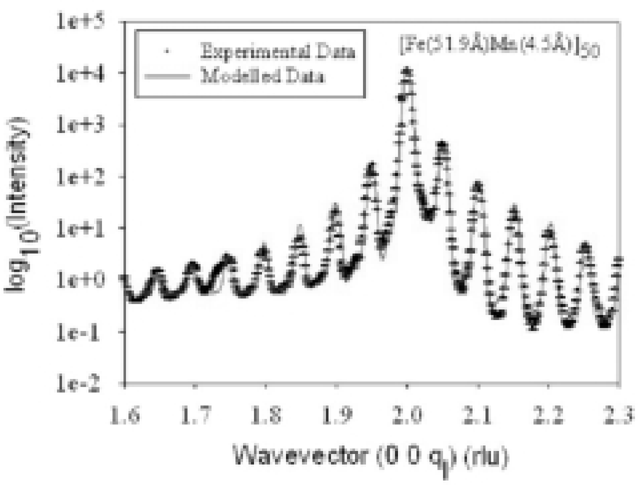

Fig. 2. Fit of structural model to typical x-ray data obtained using XMaS. The interfaces are not perfectly flat, and instead the model has terraces with a step height of about one atomic plane.

References

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[2] S. Lee *et al.*, in preparation.
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[4] J. Nogués and I. K. Schuller, *J. Magn. Magn. Mater.* **192** 203 (1999).