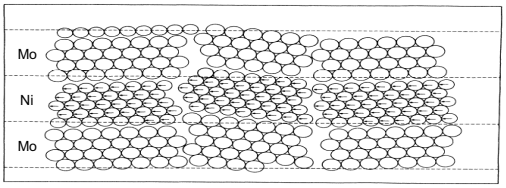
Structural and Magnetic Roughness in Multilayers

Tim Charlton, S.G.E. te Velthuis, G.P. Felcher, ANL, S. Langridge, Rutherford Appleton Laboratory, UK, L.A. Boatner, ORNL, S.K. Sinha, U. California at San Diego

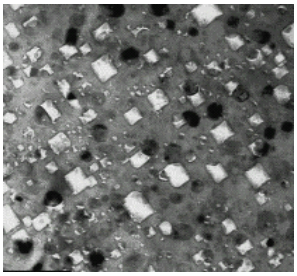
The issue: Chemical and structural interactions have different length scales. For a given chemical roughness the magnetic system might be smoother or rougher, giving rise to an intriguing and useful phenomenology in the nanometer region.

In Ni/Mo superlattices[1] the chemical roughness at the interfaces is larger than the magnetic roughness

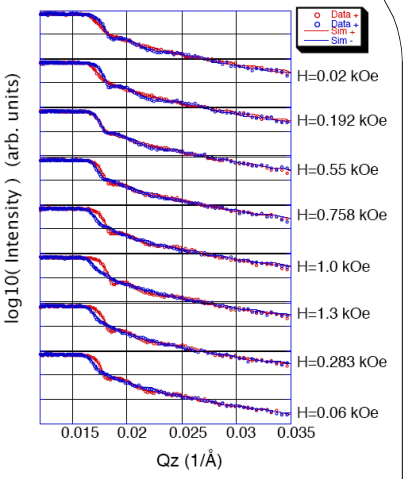


Correlation in the magnetization of quasi-periodic magnetic dots

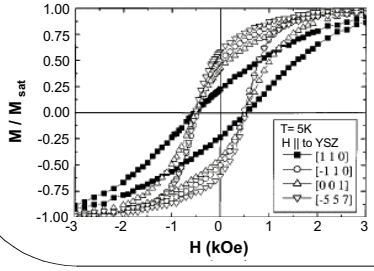
TEM image (0.5x0.5 μm) of Fe cubes embedded in a (100) oriented, yttrium-stabilized, cubic zirconia (YSZ). The a-Fe cubes, which occupy a 10% of the volume at, are oriented with respect to theYSZ host [2].

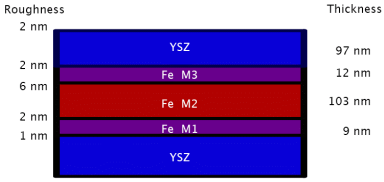


Specularly reflected neutrons measure the mean chemical potential and magnetization moment as a function of depth. Fits to the specular reflectivity are consistent with a mean depth of Fe ~160 nm below the surface.



Magnetically these ~25 nm Fe cubes are single domain with little shape anisotropy. However their hysteresis loops show a significant anisotropy due to the presence of dipolar coupling. Role of neutron scattering is to define the range of the magnetic correlations.

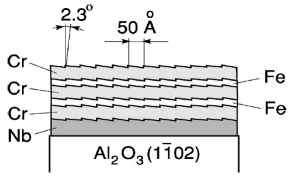




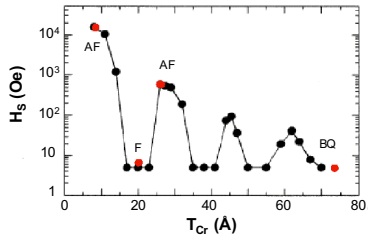
Grazing incidence neutron scattering measurements are now providing information on the lateral correlations between Fe crystallites **and** of the magnetic correlations between the same crystallites in the course of the hysteresis cycle.

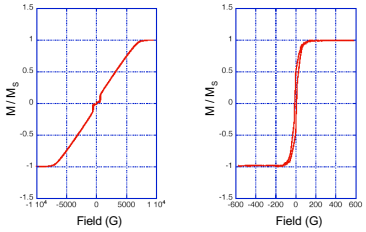
Magnetic superlattices in tilted epitaxy

In Fe/Cr superlattices, subsequent magnetic Fe layers are either AF or FM aligned depending on the Cr thickness.

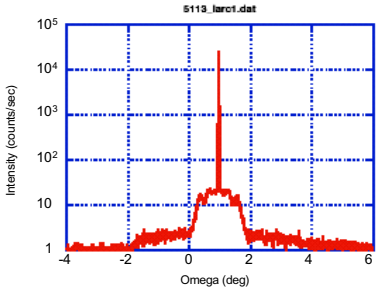


Fe/Cr superlattices grown on a special face of sapphire are characterized by a well defined saw-tooth roughness.





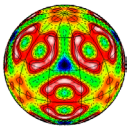
M-H loops for t_{Cr}=20 Å (left) and t_{Cr}=27 Å (right)



We designed saw-toothed Fe/Cr superlattices with different magnetic properties. Depending upon the thickness of Cr, frustration is expected to occur at the edge of the teeth, or alternatively the AF structure is expected to divide into lateral striped domains. X-rays rocking curves around the superlattice Bragg reflections (above) and polarized neutron reflectivity are fully characterizing chemical and magnetic structures.

[1] J.W. Cable, M.R. Khan, G.P. Felcher, and I.K. Schuller, Phys. Rev. B 34, 1643 (1986)
[2] L. A. Boatner, G. M. Stocks and W. H. Butler, J. Appl. Phys., Vol. 89, No. 11, 1 June 2001.

This project is part of the DOE/ISIS program for the development of neutron science at pulsed sources



BES - DOE

This work was supported by the U. S. Department of Energy, Basic Energy Sciences, under contract W-31-109-ENG-38.

MSD - ANL

ARGONNE NATIONAL LABORATORY · UNIVERSITY OF CHICAGO