Pacific Northwest Consortium

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PNC CAT

In-situ X-ray Analysis of Thin Films in MBE1

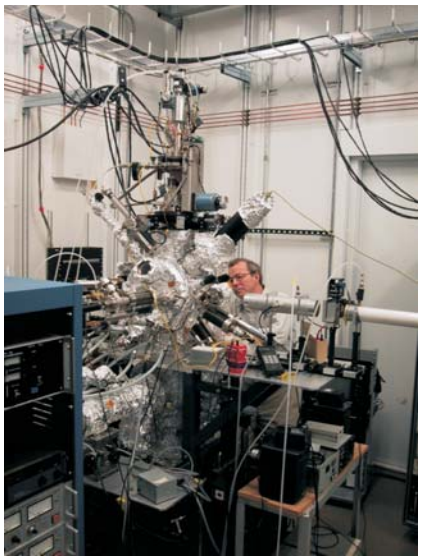

Figure 1. MBE1 table upgrade for use with toroidal mirror and insertion of multi-element detector.

MBE1 System:

MBE1 is an ultra-high vacuum molecular beam epitaxy system for use on both the undulator and bending magnet beamlines at the PNC-CAT. This system permits the growth of metal films and their characterisation *in-situ* with the polarised X-rays available at the Advanced Photon Source..

A Thermionics GB-16 3-axis/3-translation sample manipulator permits sample positioning from X-rays at normal incidence to glancing incidence with X-ray polarisation parallel or perpendicular. Azimuthal axis permits control of in-plane orientation for alignment of substrate axes with incident X-ray **k**-vector.

Operating Characteristics:

Base Pressure: $<10^{-10}$ Torr
Temperatures: -100°C to 1000°C with sample in position
Omicron EFM3 MBE sources for deposition with RHEED monitoring

Measurements:

XAFS using fluorescence, total electron yield and reflection modes
X-ray Standing Wave in back-reflection or general angle modes
Reflectivity to 15°(2θ) in either polarisation

Preliminary results: Distorted Iron films on GaAs (001)-(4x6)

R.A.Gordon, E.D. Crozier, D.T. Jiang, T.L. Monchesky and B. Heinrich (PRB, in press)

The small (1.4%) mismatch between body-centred cubic iron (*a* = 2.866Å) and GaAs (*a*/2 = 2.827Å) permits epitaxial growth of high-quality thin films and serves as a model system for the development of new magnetoelectronic devices. Determining the structures of these films is essential to understanding the magnetic behavior - the magnetocrystalline anisotropy in particular.

Analysis of the polarisation-dependent XAFS data below has revealed an in-plane (*a*) contraction and out-of-plane (*c*) expansion of the iron films that can be understood as an effort to improve (lessen) the mismatch between substrate and film. This distortion to a body-centred tetragonal structure results in a nearly constant ratio of *c*/*a* of 1.03(1) for thicknesses bettween 5 and 15 monolayers. Extensive electron-based studies of this system focused only on the in-plane structure and missed the distortion from cubic that is readily apparent with the polarised X-rays.

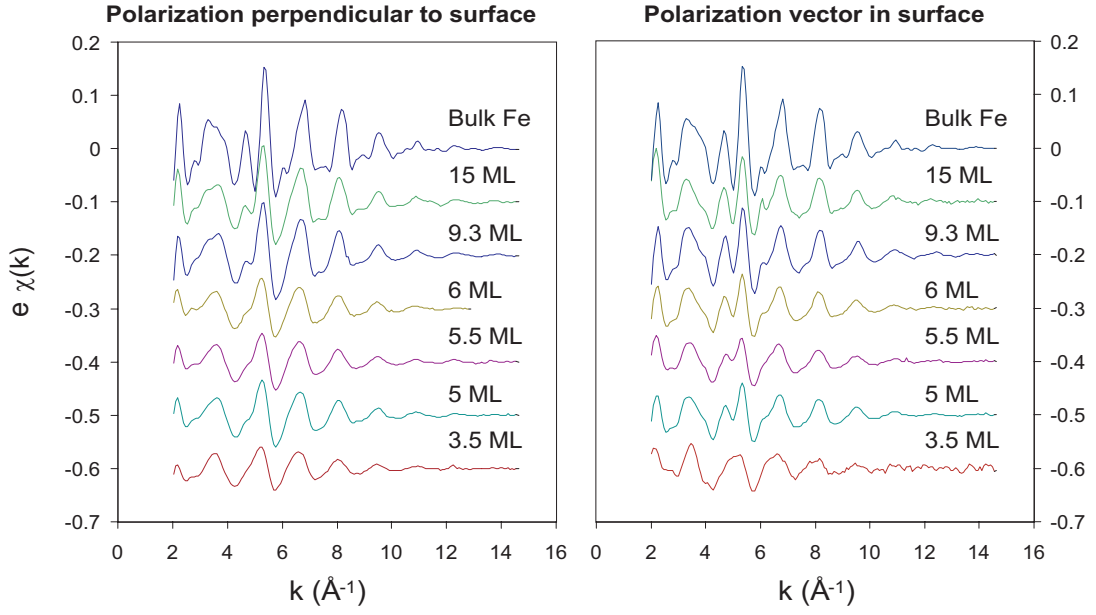

Figure 2. X-ray absorption fine structure interference functions taken *in-situ* in fluorescence mode on iron films epitaxially grown on (4x6) reconstructed GaAs(001) surfaces. The polaristaion vector of the incident X-ray beam was oriented perpendicular to (left graph) or in the plane of the substrate (right) at glancing angle. Pronounced differences are apparent in the k-space region between 2 and 5Å^{-1}.