

Magnetic Characterization of Ultra-thin Fe₃O₄ Films

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Introduction: There has recently been much interest in magnetic tunneling junctions (MTJ) as they may be the basis for the advance of Magnetic Random Access Memory (M-RAM). Much progress has been made and large magnetoresistance (MR) values in MTJ structures have been achieved despite not knowing the details of the magnetic state of the ferromagnetic layers bordering the insulating barrier, which is expected to play a dominant role in the MR. To explore these issues we have studied magnetic layered structures including Fe₃O₄ films, which are predicted to exhibit half-metallic behavior, and thus of much interest in MTJ applications. In this study, we measured XAS and XMCD spectra at the Fe L_{2,3} edge for Fe₃O₄ grown on various thin film heterostructures in order to investigate the effects of crystallographic texturing on the magnetic properties of Fe₃O₄ films.

Methods and Materials: The samples were grown by dc magnetron sputtering and were characterized by TEM and MOKE prior to XAS and XMCD measurements. Spectra were collected in the XMCD chamber at U4B using a channeltron in current mode placed in front of the samples. The incident photon beam was set to 45° relative to the sample surface normal and the samples were magnetized in the film plane. The XMCD spectra were collected with 90% circularly polarized x-rays. The resolution of the monochromator was set to ~300meV at the Fe L_{2,3} edge.

Results: **Figure 1** shows the XAS spectra of a (111) and (100) film. The electronic properties of the films are very similar as judged from the absorption spectra. XMCD measurements show magnetically similar films as well. Surprisingly, films grown on different heterostructures that had the same crystallographic orientation showed drastically different XMCD spectra. **Figure 2** shows two examples of XMCD spectra for Fe₃O₄ (100) films grown on different heterostructures. Not only has the magnitude of the XMCD signal changed, but more importantly, so has the spectral shape. This suggests then the magnetic properties of the Fe₃O₄ films depends more on the interaction of the Fe₃O₄ film with the underlying films than on the crystallographic nature of the film. This leads to the exciting possibility of tailoring the magnetic properties of Fe₃O₄ for a particular application.

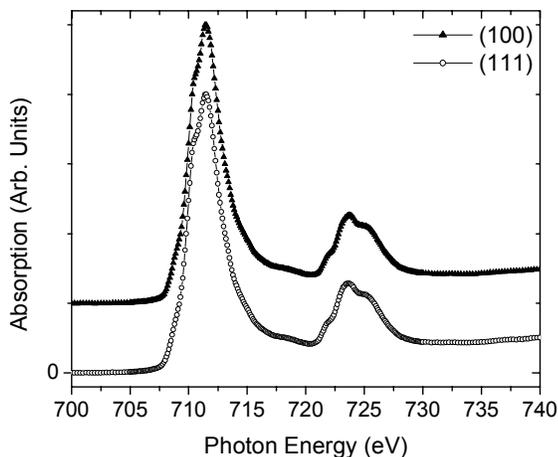


Figure 1. Typical XAS spectra across Fe L_{2,3} for Fe₃O₄ (100) and (111) films suggesting films are electronically the same.

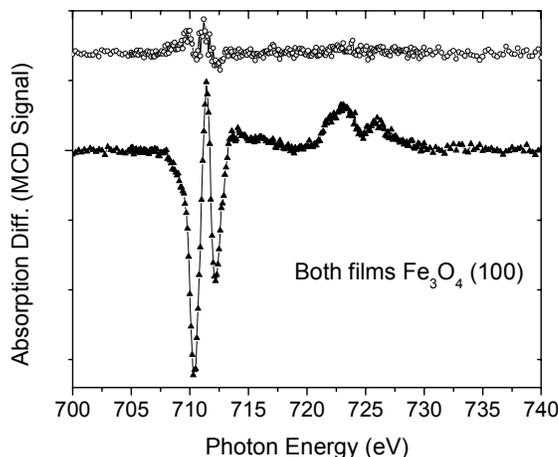


Figure 2. XMCD spectra for Fe₃O₄ (100) films grown on different thin film heterostructures.