Correlated Structural and Magnetization Reversal Studies on Epitaxial Ni Films Grown with MBE and with Sputtering

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Introduction

Metal-ceramic interfaces are important in applications as diverse as catalysis, magnetic storage media, and electrodes in spin-dependent tunneling junctions [1]. It is important to understand how the crystallography and microstructure of metallic films deposited onto ceramic substrates depend on growth and/or annealing conditions so that their physical properties (magnetic, electronic, etc.) can be tailored for specific applications. To this end, we have studied the epitaxial growth and annealing of (001) and (111) Ni and FeN films grown on MgO substrates by using different deposition techniques, such as molecular beam epitaxy (MBE) and magnetron sputtering.

Methods and Materials

The evolution of the surface has been studied by using correlated in situ reflection high-energy electron diffraction (RHEED), scanning tunneling microscopy (STM), transmission electron microscopy (TEM), and high-resolution x-ray diffraction measurements.

We have completed studies on the magnetic properties of these films, particularly the azimuthal dependence of the magnetization reversal as determined by the longitudinal magneto-optic Kerr effect (MOKE), and, in part, this research project is to correlate these findings with the structural characterization obtained with ex situ STM, TEM, and x-ray diffraction studies performed at the MHATT-CAT sector 7 beamline at the APS.

Results

From the azimuthal dependence of the coercive field and the reciprocal space maps obtained with high-resolution x-ray diffraction, we found that Ni films deposited on MgO under identical conditions with MBE and with sputtering are epitaxial films and have the same average coercivity as a result of the film’s structure. Only the film grown with MBE shows additional uniaxial anisotropy, which we believe may be due to a particular surface morphology characteristic of MBE growth.
FIG. 2. Polar plot of coercive field determined with longitudinal MOKE for (a) 30-nm (001) Ni film MBE grown on MgO and (b) 30-nm (001) Ni films sputtered on MgO. Note that only the fourfold symmetry is evident in this sample.

angle diffraction geometry and the COBRA technique are in progress to probe the interface region in more detail.

Acknowledgments
Use of the APS was supported by the U.S. Department of Energy, Office of Science, Office of Basic Energy Sciences, under Contract No.W-31-109-ENG-38.

Reference