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Magnetic anisotropies of sputtered Fe films on MgO substrates

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Abstract

Ferromagnetic resonance (FMR) and superconducting quantum interference device (SQUID) measurements have been used to study the magnetic properties of rf sputtered Fe films on MgO(001) substrates. The dependences of the FMR spectra parameters on the direction of the dc magnetic field turning in the plane of the films were measured in a wide temperature range (20400 K) for films with thickness L in the range 25500. The analysis of the angular dependence of the resonance field H0 allowed us to determine the fourfold cubic anisotropy constant K1 and the effective magnetization value Meff. It was found that both values decrease with decreasing L and approach a constant value below a certain thickness. A theory of FMR is outlined demonstrating that for the case of the dc magnetic field lying in a film plane, the anisotropy constant can be interpreted as a combination of a volume anisotropy contribution and a 1/L-dependent contribution from the surface anisotropy up to the thickness L103. This means that for the experimentally studied thickness range the films may be considered as dynamically thin films with respect to surface perturbations. Then the peculiar thickness dependence of the K1 value can be explained assuming that the relaxation of the strain due to the mismatch between film and substrate extends to distances as far as 45 from the film-substrate interface. Since our SQUID measurements show that the saturation moment does not depend on the thickness, it is concluded that the thickness dependence of the effective magnetization Meff is caused by a second-order uniaxial anisotropy arising mainly from the broken symmetry of the crystal field at surfaces and near the edges of interfacial dislocations. © 1995 The American Physical Society.

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