Magnetization and Anisotropy of Cobalt Ferrite Thin Films

Abstract:

The magnetization of thin films of cobalt ferrite frequently falls far below the bulk value of 455 kAm^{-1}, which corresponds to an inverse cation distribution in the spinel structure with a significant orbital moment of about 0.6 μ_B that is associated with the octahedrally-coordinated Co^{2+} ions. The orbital moment is responsible for the magnetostriction and magnetocrystalline anisotropy, and its sensitivity to imposed strain. We have systematically investigated the structure and magnetism of films produced by pulsed-laser deposition on different substrates (TiO_2, MgO, $MgAl_2O_4$, $SrTiO_3$, LSAT, $LaAlO_3$) and as a function of temperature (500-700°C) and oxygen pressure (10^{-4} – 10 Pa). Magnetization at room-temperature ranges from 60 to 440 kAm^{-1}, and uniaxial substrate-induced anisotropy ranges from +220 kJm^{-3} for films deposited on MgO (100) to -2100 kJm^{-3} for films deposited on $MgAl_2O_4$ (100), where the room-temperature anisotropy field reaches 14 T. No rearrangement of high-spin Fe^{3+} and Co^{2+} cations on tetrahedral A-sites and octahedral B- sites can reduce the magnetization below the bulk value, but a switch from Fe^{3+} and Co^{2+} to Fe^{2+} and low-spin Co^{3+} on octahedral B- sites will reduce the low-temperature magnetization to 120 kAm^{-1}, and a consequent reduction of Curie temperature can bring the room-temperature value to near zero. Possible reasons for the appearance of low-spin cobalt in the thin films are discussed.