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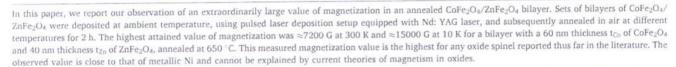
Research articles

Observation of extraordinarily large magnetization in $CoFe_2O_4/ZnFe_2O_4$ bilayers

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Ferrites with chemical formula MFe₂O₄, are composed of O²⁻, Fe³⁺ and M2+ ions (M is a single or a combination of several divalent 3d-transition metals), and crystallize with the spinel structure. Its lattice type is face centered cubic, formed by O2- ions. There are two sites, namely tetrahedral (A) and octahedral (B), in this structure that are occupied by M2+ and Fe3+ ions. Spinel ferrites are ferrimagnetically ordered. According to the Néel model, net magnetic moment of any spinel ferrite is given by ($\mu_{B^{-}}\mu_{A}$), where μ_{B} and μ_{A} are the magnetic moments on the 'B' and 'A' sites respectively, considering collinear moments in both the sites. The ferrimagnetic order results from a dominant antiferromagnetic super exchange interaction between the magnetic moments on the 'A' and 'B' sites dictating the resultant spin order in a collinear sense. The cation distribution in bulk spinel ferrites depends on the site preference of the involved divalent metal ions. A wide range of spinel ferrites with varying magnetic properties have been synthesized in the bulk over the years resulting in very useful applications [1-6]

Spinel ferrites are used in high frequency devices due to their high electrical resistivity. A major drawback is their significantly lower magnetization, when compared with many useful metallic magnetic materials. Early workers have shown an increase in magnetic moment with substitution of a non-magnetic ion like Zn^{2+} ion on the 'A' site. Substitution of Zn^{2+} ion results in an overall increase in the magnetic moment, because of reduction of μ_A . However, such a substitution can increase the magnetic moment only up to about 50% substitution on 'A'

sites. Larger substitution of the non-magnetic Zn^{2+} ion on the 'A' sites results in the weakening of the super-exchange interaction between the cations on the A and B sites. The weakening of the dominant antiferromagnetic A-B interaction causes a departure from the parallel alignment of moments on the 'B' sites, resulting in a phenomenon called canting [7–10]. Pure Zn ferrite (ZnFe₂O₄), which is devoid of magnetic ion on 'A' sites, is thus a paramagnet at room temperature and orders as a weak antiferromagnet ≈ 10 K, owing to a weak B-B interaction [11,12].

It has been observed through several experiments that the cation distribution in a nano-crystalline ferrite thin film could differ significantly from their bulk counterpart [13,14]. The cation distribution is observed to be process dependent and often results in magnetization values that are larger than its corresponding compositional bulk value. For example, in Co ferrite (CoFe₂O₄), magnetization values higher than bulk have been observed, when the films are deposited at room temperature (RT) and then subsequently annealed at temperatures TA 2 650 °C [15]. Similarly, nano-crystalline ZnFe2O4 thin films show magnetic ordering at room temperature, even though the bulk is a paramagnet [13.14]. Hence, a way to increase the magnetic moment of the spinel ferrites is to prepare the materials in nano-crystalline form and look for an enhancement of the magnetic moment. We have been studying such possibilities in double layer spinel ferrite thin films. In the present work, we report an extraordinarily large magnetization value (the highest reported value) obtained in nanocrystalline CoFe2O4/

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