Influence of Co content on the magnetic and transport properties of $Co_xFe_{3-x}O_4$ thin films grown on MgO(100) substrate using MBE

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Giant magnetoresistance(GMR), tunneling magnetoresistance(TMR), and magnetic random-access memory (MRAM) are currently active areas of research. Magnetite, Fe_3O_4, is predicted to possess as half-metallic nature, ~100% spin polarization(P), and has a high Curie temperature(T_C~850 K). On the other hand, Spinel ferrite $CoFe_2O_4$ has been widely studied for various applications such as magnetostrictive sensors, microwave devices, biomolecular drug delivery, and electronic devices, due to its large magnetocrystalline anisotropy, chemical stability, and unique nonlinear spin-wave properties. It has been reported that ions such as Mn^{2+} and Zn^{2+} have a preference to occupy the A sites, while Ni^{2+} and Co^{2+} ions tend to occupy the octahedral B sites in the inverse spinel structure. Here we report the transport and magnetic properties of $Co_xFe_{3-x}O_4$ thin films. XRD patterns confirmed the inverse spinel structure of films. Temperature dependent resistivity curves showed the Verwey transition (1st order metal-insulator transition) temperature in un-doped Fe_3O_4 film, which was disappeared in Co-doped films. The resistivity of films increased with the increasing x up to 1.6 Ω-cm for x=1. Semiconducting behavior was observed in Co-doped films. A transition at above room temperature for the sample x=1 indicates a ferromagnetic to antiferromagnetic phase transition. Magnetic properties of the doped films are sensitive to the Co-doping concentration. The magnetization curves showed a drastic increase in coercivity and decrease in saturation magnetization with Co concentration. Out of plane magnetoresistance(MR) curves at 250 K show a negative MR values with butterfly effect but was disappeared with x=1.