Influence of Co content on the transport and magnetic properties of Co$_x$Fe$_{3-x}$O$_4$ thin films on MgO (100)

Quang Van Nguyen$^1$, Christian Meny$^{2*}$, Duong Anh Tuan$^1$, Yooleemi Shin$^1$, and Sunglae Cho$^1$

$^1$Department of Physics, University of Ulsan, Ulsan 680-749, Korea
$^2$Institute of Physics and Chemistry for Materials of Strasbourg, UMR 7504 UDS-CNRS, Strasbourg, 67034, France

Giant magnetoresistance, tunneling magnetoresistance, and magnetic random-access memory are currently active areas of research. Magnetite, Fe$_3$O$_4$, is predicted to possess as half-metallic nature, $\sim$ 100% spin polarization, and high Curie temperature (850 K). Microcrystalline ferrites are used as a medium for the magnetic recording and storage of information.[1] It’s reported that Fe$_3$O$_4$ is a ferrimagnet with a cubic inverse spinel structure and exhibits a Verwey transition at about 120 K.[2] The electrical and magnetic properties of bulk ferrites are found to be sensitive to grain size, grain structure, doping content, porosity and distribution of the metal cations among the lattice sites in the spinel structure.[3] Cobalt ferrite is one of the most important member of the ferrite family, which is characterized by its high coercivity, moderate magnetization and very high magnetocrystalline anisotropy.

Here we report the transport and magnetic properties of Co$_x$Fe$_{3-x}$O$_4$ ($0 \leq x \leq 1$) thin films grown on MgO (100) substrate by MBE. XRD patterns confirmed the inverse spinel structure of films. The Verwey transition was found in un-doped Fe$_3$O$_4$ film, and disappeared in Co-doped films. The electrical resistivities of films were increased with increasing $x$ up to 1.6 $\Omega$-cm for $x = 1$. Semiconductor behavior was observed in Co-doped films. A transition at above room temperature for the sample $x = 1$ was suggested as a ferromagnetic to antiferromagnetic phase transition. Magnetic properties of the Co-doped films are markedly sensitive to the Co-doping concentration. Out of plane magneto-resistance curves at 250 K showed a negative transverse with butterfly effect but disappeared with $x = 0.8$ and 1.