

Effective magneto-crystalline anisotropy in ordered Co nanowire array

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ABSTRACT

The vortex structure in nano-dimensional magnet is of considerable technological interest in data storage due to the low magnetic stray field, which leads to a high magnetic stability and also minimizes the cross-talk between adjacent vortices. We demonstrate that the formation of vortex core in a bi-layer textured growth of ordered Co nanowire (NW) arrays embedded in porous anodic alumina membrane (Fig 1 (a)). Co NWs with diameter of ~ 70 nm (Fig 1 (b)) and length (L) of 2000 nm have been deposited into pores of alumina template by pulse electrochemical route at room temperature. The structural investigations by X-ray diffraction indicate the textured Co NW growth of hcp (002) structure at the bottom, while the upper portion ($L \geq 500$ nm) grows in hcp (100) texture (Fig 1 (c)). The magnetic properties of the NWs arrays reveal the reduction in magneto-crystalline anisotropy as a function of wire length, though the shape anisotropy in 1D system keeps the magnetization easy axis parallel to the wires. To understand these magnetic anomalies, micro-magnetic simulation has been carried out and the above observations were correlated with the formation of bi-layer structures of two different crystallographic textures; hcp (002) and hcp (100). While carrying out the simulation, the whole length of the nanowires was divided into three different crystallographic regions: the lower part having hcp (002) with section length of 300 nm, the middle part having mixed texture of hcp (100) and hcp (002) with section length of 200 nm and the remaining upper part having hcp (100) texture (see Fig. 2). The simulated M(H) curves match quite well with measured M(H) curves (see Figs 1(d) and 2(a)). Interestingly, the simulation data revealed decrease in magneto-static interactions among the NWs in an array with the formation of (100) texture. The perfect hcp (100) shows two vortex states with an equal and opposite chiralities, whereas, the bi-layered structure shows a crossover from a coherent to a single vortex state along the wire axis. The formation of vortex core with high M_r/M_s ratio may lead into the promising applications such as magnetic random access memory, high-density magnetic recording media, and magnetic switching system.

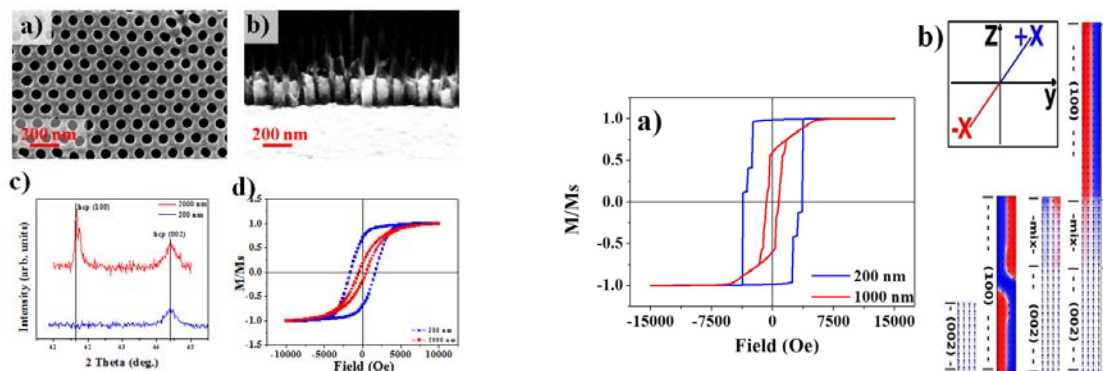


Figure1. Experimental Co NWs: FESEM, a) Top AAO, b) Co NWs with filled porous alumina, c) XRD and d) M-H curve of Co NWs parallel to wire axis for $L = 200$ and 2000 nm. Figure2. Simulated Co NWs: a) M-H curve and b) magnetic domains.

References

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