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NdFeB/FeCo Exchange Spring Thin Film Magnet with Perpendicular Magnetic Anisotropy

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Exchange spring magnet composes multilayers of hard magnetic phase with high uniaxial anisotropy and soft magnetic pase with high saturation magnetic induction. The hard magnetic pase and the soft magnetic phase are exchanded coupling with each other. Exchange spring magnet are expected to show high energy product at optimizaed films structure and materials. In this paper, we show our effort to prepare exchange spring magnet composed of $Nd_2Fe_{14}B$ (K_u = 4.6 × 10^6 J/m^3) and $Fe_{65}Co_{35}$ (B_s is about 24.5 T). Of perticular interest is that at optimized condition, magnet films show perpendicular magnetic anisotropy.

NdFeB/FeCo multilayered films were deposited by DC magnetron sputtering. The base pressure is below 5.0 × 10^{-5} Pa. The deposition of films was performed in an argon pressure of 1.3 Pa. To introduce perpendicular magnetic anisotropy, W unerlayers with (110) orientation was first deposited onto thermally silicon wafer. Two different ways are used to achieve magnetic hard films. The first is post-annealing and the second is substrate heating. In the former case, Multilayers were deposited without substrate heating. Magnetic hard films were obtained by post-annealing. In the latter case, Multilayers were directly deposited onto heated substrate at temperature of 425 ^oC. The obtained magnetic films were characterized by a vibrating sample magnetometer and an X-ray diffractometer.

Experiemntal results show that coercivities of the films decrease with the increase of the FeCo layer thickness. Films with FeCo layer thickness higher than 30 nm show a “step” in the hysteresis loop. This is the typical hysteresis of films composed of both hard and soft magnetic phase. While films with FeCo layer thickness thinner than 30 nm show the typical behavior of spring magnet. The hard phase and the soft phase are strongly exchanged with each other. The hysteresis loop show only single hard magnetic phase. Those results indicate that the exchange length of FeCo is around 30 nm. Which is consistant with the calcalated value of 26 nm. Films prepared by post annealing show random orientation. However, films prepared by substrate heating show perpendicular magnetic anistropy. This can be concluded by the eptaxial grwoth of $Nd_2Fe_{14}B$ (00l) plane onto FeCo (110) plane. Since the two planes have an misfit ratio as small as 6.4 %.

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Structure and Magnetic Properties of Co-Ni-Cu/Cu Nanowires Electrodeposited in Track-etched Polyester Template

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The controlled production of superlattice magnetic nanowire arrays with outstanding characteristics is attracting much interest recently owing to their applications in emerging technologies related with magnetic information storage. Template electrodeposition is an efficient approaching method to fabricate these magnetic nanowires. We have recently demonstrated that Co-Ni-Cu/Cu nanowires electrodeposited in polyester nanoporous (PETE) templates exhibit giant magnetoresistance behaviour which is consistent with the Valet-Fert theory in terms of the formation of high quality multilayers structure [1].

In this paper we report on the microstructure and magnetic properties of Co-Ni-Cu/Cu nanowires electrodeposited in polyester template. Multilayered nanowires were made from a single bath and their properties were studied using scanning electron microscopy (SEM), transmission electron microscopy (TEM), X-ray diffraction (XRD), magnetic force microscopy (MFM) and superconducting quantum interface magnetometry (SQUID) techniques. Bright field TEM images show sharp magnetic/non-magnetic layer interface perpendicular to the wire axes. Selected area diffraction patterns reveal the formation of satellite peaks along with the possible preferential growth <110> or <111> direction. XRD spectrum of Co-Ni-Cu 3.3 nm/Cu (tCu) with tCu=3.3-14 nm consists of <111> fundamental peak with satellite peaks. The periodicity of bi-layers calculated by the theoretical equation is consistent with the nominal bi-layer thickness. This observation of satellite peaks can be a clear confirmation of high quality of the nanowires associated with a preferential groth direction along <111>. Magnetic force micrographs taken above the filled template indicate that the detected magnetic response decreases with increasing the copper layer thickness which can be due to either weaker exchanged coupled magnetic layers or less amount of total magnetic moments. The magnetisation curves at 20 K of the nanowires show a rotation of easy axis direction from out of the plane to in the plane, as Cu layer thickness (tCu) increases in a range of 0.5~26 nm.

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REFERENCES

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