Atomistic simulations and magnetic properties of Co/Tb-Co bilayers

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Ferrimagnetic RE-TM films (RE-rare earth, TM-transition metal) are experiencing renewed interest for applications such as spintronics and all-optical switching. It has previously been demonstrated that ion bombardment (IB) can be used to modify the properties of ferrimagnetic RE/TM multilayers primarily due to preferential oxidation of RE after bombardment [1,2]. In this work we show that the addition of a Co underlayer can also be used to tailor magnetic properties of Tb-Co alloy films. Several Co/Tb-Co bilayer systems deposited by magnetron co-sputtering in which the Tb-Co alloy layer was prepared with mutually perpendicular gradients of Tb concentration ($16 \leq c_{Tb} \leq 59$ at. %) and thickness ($3 \leq t_{alloy} \leq 10$ nm) as detailed in Ref. [3]. The thickness of the Co underlayer (t_{Co}) was kept uniform ($t_{Co} = 0.5$, 1.0, 2.0, 4.0 nm). The magnetic characterization of the samples was performed using PMOKE magnetometry.

This allowed us to determine which combinations of layer thicknesses and RE concentration allow simultaneous magnetization reversal of both layers, maintain perpendicular magnetic anisotropy, and show that the addition of the Co underlayer shifts the compensation point towards higher c_{Tb}. At a specific composition ($c_{Tb} \gtrapprox 40$ at. %), a second compensation point was observed where the sublattice domination changes from Tb to Co. At this composition, the Tb-Co layer is expected to be paramagnetic at room temperature [4].

Atomistic simulations using the Vampire package [5] were used to provide an understanding of the mechanisms responsible for the observed features. An atomistic approach is ideal for ferrimagnetic systems because it allows for the consideration of the individual sublattices. In particular, cross-sectional profiles of the magnetization of the system for varying temperature indicate that a small part region of the paramagnetic Tb-Co layer exhibits spontaneous magnetization close to the Co/Tb-Co interface. The simulations reveal that, close to the interface between the two layers, a small part of the paramagnetic alloy layer exhibits spontaneous magnetization, causing the system to behave as a ferrimagnet with Co domination due to a proximity-induced spin polarization.

References:

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