Contact magnetoresistance of multilayered Co/Cu nanostructures measured by scanning tunneling microscope

by

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ABSTRACT

Oblique angle deposition (OAD) is used to create a new F/N system that exhibits current-perpendicular-to-plane giant magnetoresistance (CPP-GMR) at room temperature. Using dual source thermal evaporation, slanted or vertical multilayered Co/Cu nanocolumns were deposited with layer thicknesses t_l = 4-16 nm and bilayer number M = 21-50. Scanning and transmission electron microscopy (SEM/TEM) show the nanocolumns to have diameters d = 40-100 nm and areal densities σ = 70-100/μm^2. Electron energy-loss spectroscopy (EELS) imaging on individual slanted columns with t_l = 16 nm show a clear multilayered Co/Cu structure. X-ray diffraction (XRD) pole figure measurements performed on the slanted columns show a weak Co(111) texture tilted at ~30° from normal towards the incident flux stemming from epitaxial growth of Co on Cu.

A nonmagnetic STM module was constructed for localized (sub-μm) GMR measurements without artifacts due to the small contact size. CPP-GMR values of 0.2-2.3 % were observed in the multilayered Co/Cu nanocolumns (with higher GMR for lower t_l), which is much smaller than the values reported for other wire-like F/N systems at room temperature. Despite the low GMR values, the GMR for samples with different t_l values could be distinguished, and the dependence of GMR on t_l could be fit by the spin diffusion-based Valet-Fert (VF) model using reported material parameters and a very low spin diffusion length l_{sf}^{Cu} = 3-5 nm. The low l_{sf} value is consistent with the increased resistivity of these samples, which was estimated to be about an order of magnitude larger than bulk Cu and Co. Both GMR and vibrating sample magnetometry (VSM) measurements show weak in-plane anisotropy, which may be useful for direction-based magnetic sensing if the GMR value can be increased.

Future work includes further study of the magnetic anisotropy using VSM and micromagnetic simulations, as well as modifications to the fabrication technique to improve sample quality. Since the reason for the low GMR is probably the growth front roughness, a deposition method with increased incident adatom energy, such as sputtering may help to smooth the growth front.