Soft magnetic properties of sub 10 nm NiFe and Co films encapsulated with Ta or Cu

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Magnetic properties of NiFe and Co thin films with thicknesses ranging from 2.5 to 10 nm have been studied. The thickness range we considered is of current interest from the viewpoint of giant magnetoresistive device fabrication such as sensors and memories., but has been less explored. The purpose of this study is to understand the thickness effects on magnetic properties such as coercivity, anisotropy field, and magnetostriction. NiFe and Co films were deposited by sputtering under 5 mTorr Ar environment. The base vacuum pressure was less than $5x10^{-8}$ Torr. These films were encapsulated with 5 nm Ta and Cu layers, commonly used for underlayer, capping and spacer materials for spin-valve sensors. Magnetic properties were characterized by BH loop tracing, magneto-optic Kerr effect, and laser deflection (for magnetostriction) methods. Unlike previous results from ion-beam deposited Cu 5 nm/NiFe (t <10 nm)/Cu 5 nm structures [1] indicating a monotonic decrease in easy axis coercivity (H_c) as a function of film thickness reduction, our data exhibit an increase in H_c up to about 3 Oe at t = 5 nm. H_c results from Ta 5 nm encapsulated NiFe samples show a similar behavior compared with the previous result [1]: a monotonic decrease in H_c as film thickness reduced. Co samples with Cu encapsulations show a large increase in H_c, while those with Ta exhibit an abrupt decrease yielding H_c <5 Oe at t = 2.5 nm. The saturation magnetostriction (λ_s) values of the Cu encapsulated samples are about an order of magnitude smaller compared with the Ta encapsulated ones. In addition, NiFe samples exhibit an order of magnitude smaller magnetostrictions than Co samples.

References

[1] M. Ueno and S. Tanooue, J. Vac. Sci. Technol. A **13**, 2194 (1995).