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ABSTRACTS

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Session DE

TUNNEL MAGNETORESISTANCE

DE-02. Utilizing Superparamagnetic Freelayers for Magnetoresistive Sensors. *J.E. Davies*[1], P. Eames[2], M.A. Torija[1] and C. Nordman[1]
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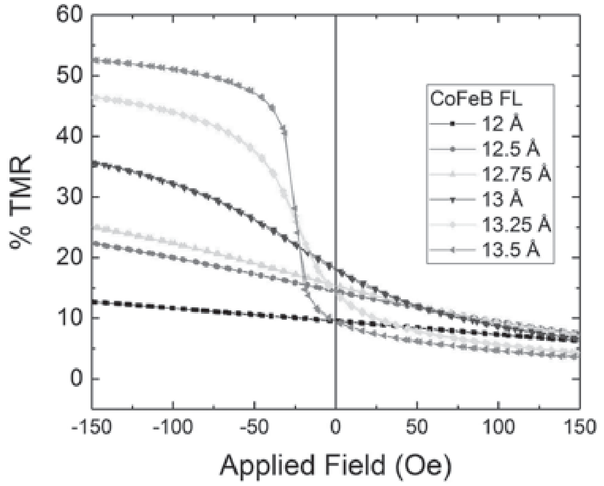
Giant and tunneling magnetoresistance (GMR/TMR) technologies have provided significant gains in sensitivity and allowed for drastic decreases in size and power consumption. Continued reduction in form factor while improving detectivity remains a key challenge [1]. Also, for analog operation it is desirable to have no hysteresis. Being that GMR/TMR sensors contain ferromagnetic materials, this is a non-trivial problem. One approach is to develop free layer (FL) materials near the room temperature superparamagnetic limit. Such FLs offer a number of advantages including: zero hysteresis, extremely small hard axis response and independence of sensor response from lithographic patterning. This study focuses on magnetic tunnel junction devices comprised of a traditional IrMn bottom pinned synthetic antiferromagnet, MgO barrier and ultra-thin (ranging between 1 nm and 1.5 nm) CoFeB free layer. Varying the FL thickness we are able to transition between a fully superparamagnetic state and a hysteretic "full layer" performance. The full superparamagnetic state results in substantially suppressed tunneling magnetoresistance (TMR). As the FL thickness is increased a transition region is observed where a substantial increase in sensitivity with near zero hysteresis occurs, however, offset from Neél (orange peel) coupling becomes prominent (Fig. 1). Hard-axis response increases substantially with film thickness increase as well. Instead of increasing the thickness further, incorporation of spacer materials, such as tantalum, results in a substantial increase in the sensitivity. Such insertion layers have been shown previously to enhance perpendicular magnetic anisotropy, often attributable to broken symmetry at the interfaces [2]. However, at these thicknesses where the FL is composed of isolated grains it is more likely that the insertion layer provides an alloying effect helping FL grain formation. We show these films to have minimal off-axis characteristics and have been demonstrated to be geometry independent. Efforts currently focus on alleviating challenges in the temperature performance due to $K_uV >> k_bT$.

[1] W. F. Egelhoff, P. W. T. Pong, J. Unguris, R. D. McMichael, E. R. Nowak, A. S. Edelstein, J. E. Burnette, and G. A. Fischer, "Critical challenges for picoTesla magnetic-tunnel-junction sensors," *Sensors Actuators A Phys.*, vol. 155, no. 2, pp. 217–225, Oct. 2009. [2] J. M. Daughton and D. Wang, "Superparamagnetic Platlets Field Sensing Devices," U.S. Patent No. 7,660,081, 2008. [3] S. Ikeda, K. Miura, H. Yamamoto, K. Mizunuma, H. D. Gan, M. Endo, S. Kanai, J. Hayakawa, F. Matsukura, and H. Ohno, "A perpendicular-anisotropy CoFeB-MgO magnetic tunnel junction.," *Nat. Mater.*, vol. 9, no. 9, pp. 721–4, Sep. 2010



Evolution of the resistance versus applied magnetic field curves for MTJs with FLs ranging from 12 Å to 13.5 Å.