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Tuning of Indirect Exchange Coupling in FePt/Al_2O_3/Fe_3Pt System

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Abstract : The indirect exchange coupled system consists of two ferromagnetic layers separated by non-magnetic spacer layer. The type of exchange coupling may be either ferro or anti-ferro depending on the thickness of the spacer layer. In the present work, the strength of exchange coupling in FePt/Al_2O_3/Fe_3Pt has been investigated by varying the thickness of the spacer layer Al_2O_3. The FePt/Al_2O_3/Fe_3Pt trilayer structure is fabricated on Si <100> single crystal substrate using sputtering technique. The thickness of FePt and Fe_3Pt is fixed at 60 nm and 2 nm respectively. The thickness of spacer layer Al_2O_3 was varied from 0 to 16 nm. The normalized hysteresis loops recorded at room temperature both in the in-plane and out of plane configuration reveals that the orientation of easy axis lies along the plane of the film. It is observed that the hysteresis loop for ts=0 nm does not exhibit any knee around H=0 indicating that the hard FePt layer and soft Fe_3Pt layer are strongly exchange coupled. However, the insertion of Al_2O_3 spacer layer of thickness ts = 0.7 nm results in appearance of a minor knee around H=0 suggesting the weakening of exchange coupling between FePt and Fe_3Pt. The disappearance of knee in hysteresis loop with further increase in thickness of the spacer layer up to 8 nm predicts the co-existence of ferromagnetic (FM) and antiferromagnetic (AFM) exchange interaction between FePt and Fe_3Pt. In addition to this, the out of plane hysteresis loop also shows an asymmetry around H=0. The exchange field Hex = ($Hc\uparrow$-$HC\downarrow$)/2, where $Hc\uparrow$ and $Hc\downarrow$ are the coercivity estimated from lower and upper branch of hysteresis loop, increases from ~ 150 Oe to ~ 700 Oe respectively. This behavior may be attributed to the uncompensated moments in the hard FePt layer and soft Fe_3Pt layer at the interface. A better insight into the variation in indirect exchange coupling has been investigated using recoil curves. It is observed that the almost closed recoil curves are obtained for ts= 0 nm up to a reverse field of ~ 5 kOe. On the other hand, the appearance of appreciable open recoil curves at lower reverse field ~ 4 kOe for ts = 0.7 nm indicates that uncoupled soft phase undergoes irreversible magnetization reversal at lower reverse field suggesting the weakening of exchange coupling. The openness of recoil curves decreases with increase in thickness of the spacer layer up to 8 nm. This behavior may be attributed to the competition between FM and AFM exchange interactions. The FM exchange coupling between FePt and Fe_3Pt due to porous nature of Al_2O_3 decreases much slower than the weak AFM coupling due to interaction between Fe ions of FePt and Fe_3Pt via O ions of Al_2O_3. The hysteresis loop has been simulated using Monte Carlo based on Metropolis algorithm to investigate the variation in strength of exchange coupling in FePt/Al_2O_3/Fe_3Pt trilayer system.

Keywords : indirect exchange coupling, MH loop, Monte Carlo simulation, recoil curve
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