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Development of Exchange Bias in $IrMn_3$ Based Magnetic Tunnel Junctions

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Magnetic tunnel junctions (MTJs) are promising nanostructures for Magnetoresistive Random Accesss Memories (MRAMs)[1]. The exchange bias of the pinned layer adjacent to the AFM (antiferromagnet) is a critical parameter determining the stability of the spin valve devices. Most of the MTJs studied in the literature show exchange bias in the as deposited state itself even before annealing in presence of a magnetic field [2]. Annealing is carried out in MTJs with a twin purpose of homogenization of oxide layer to enhance transport properties and to improve exchange bias. In the MTJs reported here we get a pseudo spin valve (PSV) type structure in the as deposited state with no exchange bias which develop exchange bias and high TMR values up to 38% after field annealing. As a result we have been able to investigate the development of exchange bias on field annealing from the no bias state in the as deposited films. Tunnel junctions with the structure Ta (50 Å)/Cu (100 Å)/Ta (50 Å)/Ni-Fe (20 Å)/Cu (50 Å)/(100 Å)/$Co_{70}Fe_{30}$ (25 Å)/Al-O/$Co_{70}Fe_{30}$ (25 Å)/ Ni-Fe (600 Å)/ Ta (50 Å) were prepared on thermally oxidized Si wafers using DC magnetron sputtering in a chamber with a base pressure of 3×10^{-9} Torr. In the VSM and TMR measurements of as deposited MTJs, a narrow loop with coercivity around 5 Oe corresponding to the free layer, and a loop with a large coercivity above 500 Oe with a wide distribution in reversal fields corresponding to the pinned layer, are observed. After field annealing at 250 °C in a magnetic field of 1 kOe, both the VSM loop and the MR loops show substantial shifts of around 1000 Oe from zero field for the pinned layer and a 5 Oe shift for the free layer. The loops corresponding to both the free and pinned layer show much sharper switching behavior after annealing. We get the no bias state in as deposited state presumably due to the low magnetic field of 30 Oe employed during deposition. However, our results for the field annealed samples show that we can get good magnetoresistive properties in our MTJs after annealing despite the low deposition fields and no bias state in the as deposited films

References

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