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Magnetoelectric properties of double barrier magnetic tunnel junctions with variable Co-Fe-B middle free layer

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Double barrier magnetic tunnel junction (DBMTJ) is interesting from the physical and the application point of view due to higher $V_{1/2}$ value (at which the zero bias TMR value is halved) and also suitable for investigating the spin-polarized electron coherent tunneling and oscillatory tunnel magneto-resistance effect.[1-4] Moreover, it has potential application for developing spin-transistors.

In this work, double barrier magnetic tunnel junctions with the elliptic size of $2\times4\pi$ μm^2 and stack layer structure of Ru(5)/Cu(10)/$Ni_{79}Fe_{21}$(5)/$Ir_{22}Mn_{78}$(12)/ $Co_{60}Fe_{20}B_{20}$(4)/Al(1.2)-O/$Co_{60}Fe_{20}B_{20}$(*d*)/Al(1.2)-O/$Co_{60}Fe_{20}B_{20}$(4)/$Ir_{22}Mn_{78}$(12)/ $Ni_{79}Fe_{21}$(5)/Ru(5) (layer thickness unit: nm, and d=0.8, 1.0, 1.25, 2.0, 3.0, 4.0, 5.1, 6.2, 7.0, 8.0, 10.0, and 12.0 nm) were micro-fabricated. The magneto-electric properties of these DBMTJs with variable Co-Fe-B middle free layer were investigated.

Our experimental results shown that when the $d<1.25$ nm the DBMTJ has small TMR ratio like granular MTJ properties, when the 1.25 nm $\leq d \leq$12.0 nm the DBMTJ has large TMR ratio like normal MTJ properties, and when the d=6.2 nm the DBMTJ has maximum TMR ratio of 59.4% as shown in Fig.1.

Fig.2 shows the TMR curves and bias dependence of the normalized TMR value measured at room temperature (RT) for a typical DBMTJ with d=4.0 nm after annealed at 275 °C for an hour. The TMR value of 43% and resistance-area product (RS) of 3.76 $k\Omega\cdot\mu m^2$ were obtained at RT. The $V_{1/2}$ values are estimated to be over than 1.5 V up to 1.9 V (extrapolated) for positive and negative bias. The $V_{1/2}$ enhancement is produced by the reduction of the effective bias voltage applied to the individual two barriers. It can be seen that there is a slightly asymmetric bias voltage dependence of the TMR, which is distinctly improved compared with that in the reference [3] ($V_{1/2}$ of +1.44 and -0.72V for positive and negative bias). The asymmetry is due to the subtle differences in the Co-Fe-B/Al-O interfaces. Such DBMTJs are promising candidates for spin-electronic device applications.

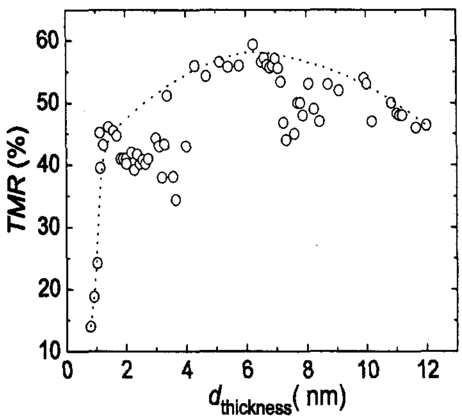

Fig.1 The thickness dependence of $Co_{60}Fe_{20}B_{20}$ middle free layer versus TMR ratio for the DBMTJs at room temperature.

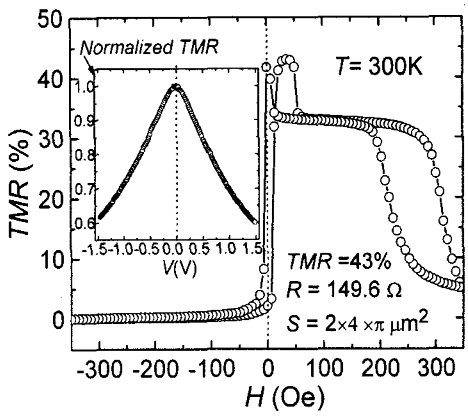

Fig.2 TMR major curves and the bias dependence of normalized TMR (inset) measured at RT for a typical DBMTJ with d=4.0 nm.

Reference

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