Poster

NANO-SIZED MGO-BASED MAGNETIC TUNNEL JUNCTIONS FABRICATED BY E-BEAM LITHOGRAPHY COMBINED WITH CHEMICAL-MECHANICAL POLISHING

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In this work a new nanofabrication method was used to integrate nano-sized (down to $48x180nm^2$) MgO-based magnetic tunnel junctions (MTJs) in to complete current-perpendicular-to-plane (CPP) devices.

This alternative fabrication process combines micro and nano direct-write lithography techniques. The active elements are defined by electron beam and patterned by ion milling, while bottom and top electrodes are defined by conventional laser lithography. Chemical Mechanical Polishing (CMP) of SiO_2 passivation/planarization film allows contact to the top electrode of the buried pillar [2]. The TMR is calculated as $(R_{high}-R_{low})/R_{low}$, where R_{low} is the low resistance state, and R_{high} is the high resistance state.

The samples presented in this abstract show the successful working and reproducibility of this process. The sucture of the samples presented are:

- Samples 1/2/3 (from IBD):

Ta(50)/Ru(200)/Ta(50)/MnIr(150)/CoFe(20/30/20)/Ru(8)/CoFeB(40)/MgO(7/7/10)/CoFeB(30/20/30)/Ru(30)/Ta(100)

- Samples 4/5 (from PVD):

Ta(50)/Ru(180)/Ta(30)/PtMn(160)/CoFe(20/24)/Ru(9/9.6)/CoFeB(30)/MgO(11/7)/CoFeB(30/15.5)/Ru(50)/Ta(50)

The device resistance is plotted vs 1/Area for samples 1, 2, 3 and 4 in Figure 1, exhibiting the expected linear dependence. From this figure the RA characteristic of each sample can be extracted: $RA_{SAMPLE\ 1} \sim 0.8\ \Omega.\mu m^2$, $RA_{SAMPLE\ 2} \sim 1\ \Omega.\mu m^2$ and $RA_{SAMPLE\ 3} \sim 15\ \Omega.\mu m^2$ $RA_{SAMPLE\ 4} \sim 50\ \Omega.\mu m^2$. These MTJs, as a current-perpendicular-to-plane device, show a constant (controlled by the MgO barrier). In figure 2 is summarized the dependence of the tunnel magnetoresistance (TMR) on the RA product [3]. A decrease of TMR is observed for samples with thinner MgO, so that the TMR values of the samples with 0.7 and 0.75 nm thick MgO range from 20-50%. For a sample deposited by PVD with a MgO barrier of 1.1 A can reach TMR values of 200%. For the low resistance devices (from sample 1) current induced switching was measured. Figure 3 shows the transfer curve obtained under an external applied magnetic field (TMR 25% RA=0.82 $\Omega.\mu m^2$). Spin transfer was demonstrated (under a constant +35 Oe bias field), at critical current of $2.6x10^7$ A/cm^2, with the same resistance change (25%)

References:

[1] European Patent EP1212777 "Ion Beam vacuum sputtering apparatus and method", M.Davis, G.Proudfoot and D.Pearson (2001)
[2] R. J. Macedo, J. Sampaio, J.Loureiro, P.Wisniowski, S. Cardoso and P. P. Freitas, IEEE Trans.Nanotech. (submitted 2007)
[3] S.Cardoso, R.Macedo, R.Ferreira, A.Augusto, P.Wisniowski and P.P.Freitas, J.Appl.Phys. (in print)

Figures:

Figure 1: Resistance versus 1/A for samples 1, 2, 3 and 4. the insets shows SEM pictures of selected junctions areas.

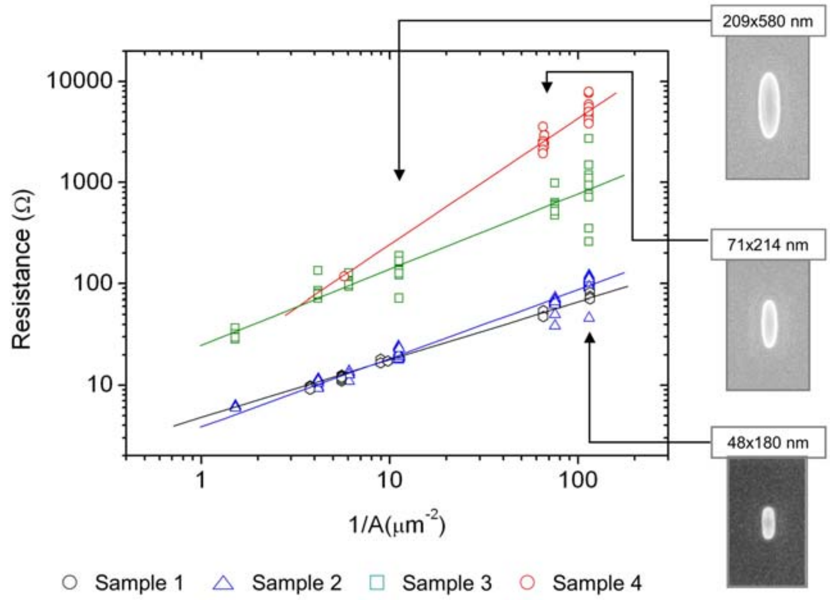

Figure 2: TMR an RA product as a function of MgO barrier thickness**.**

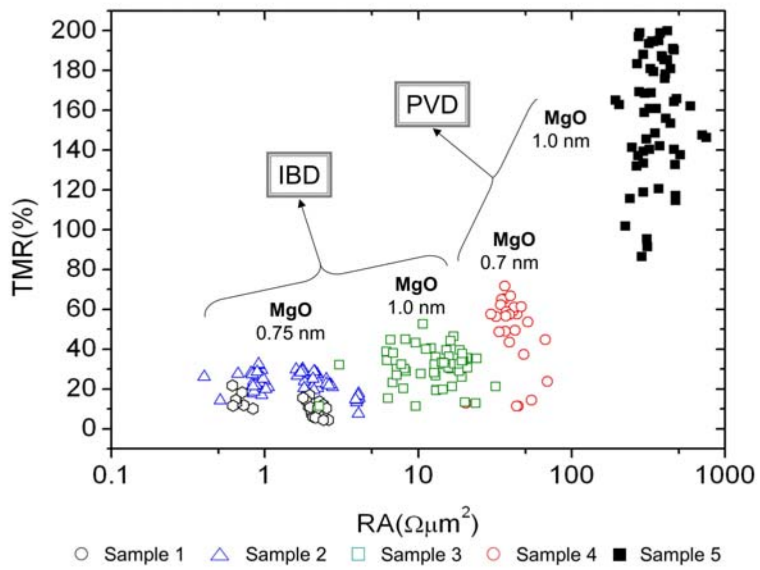

Figure 3: Right:Sample transfer curve.Left: spin transfer switching of the same MTJ element.