Strongly suppressed 1/f noise and enhanced magnetoresistance due to reduced interface mismatch in epitaxial Fe<V>/MgO /Fe magnetic tunnel junctions

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It is well known that there is a small (about 4%) lattice mismatch between Fe and MgO that induces stress within MgO barrier, which is usually relaxed via dislocations and defects. These are responsible for the reduced TMR below its maximum value and also determine substantially the defect related 1/f noise. Recent attempts [1] to increase the tunnelling magnetoresistance (TMR), but only for relatively thick MgO barriers, have been focused on implementing some Fe alloy as ferromagnetic electrode to reduce the interface lattice mismatch.

In accordance with the previous report [1] alloying of Fe with V for the bottom electrode slightly improves the TMR value (Fig. 1a). We have also studied the evolution of the coercive field of soft and hard layers as function of the V doping (Fig 1b). Our findings suggest that changing the Vanadium doping of the electrodes we could tune TMR and modify the coercive field of the ferromagnetic layers.
The main result of our studies is experimental observation that the alloying of the Fe with V, through the reduced FeV/MgO interface mismatch in epitaxial magnetic tunnel junctions (MTJ´s) with MgO barriers, notably suppress both nonmagnetic (parallel state) and magnetic (antiparallel state) normalised 1/f noise as well as enhances the TMR. Comparative study of the room temperature electron transport and low frequency noise in $Fe_{1-x}V_x$/MgO/Fe and Fe/MgO/$Fe_{1-x}V_x$ MTJs with ($0<x<0.25$) reveals that relatively small Vanadium doping of the bottom electrode for $x<0.16$ reduces the normalized nonmagnetic 1/f noise (Hooge factor) in nearly 2 orders of the magnitude with moderate (about 10 %) increase of the TMR (Fig 2a). We attribute the enhanced TMR and suppressed 1/f noise to reduced misfit and dislocation densities. We also note that the doping provides minimum values of the nonmagnetic noise also corresponds to the maximum TMR values of about 200%.

For the further doping we found that the normalized nonmagnetic noise increases its value and the TMR decreases (Fig.2). Although the previous work [1] has demonstrated that increasing **x** should continue to decrease the lattice mismatch, we think that these results might be related to an increased structural disorder at FeV/MgO interface with increasing number of Fe or V atoms located in the metastable states. On the other side, we show that Vanadium substitution of the upper electrode results in a gradual suppression of the TMR and increasing of the nonmagnetic noise which is in accordance with structural analysis indicating growing influence of accumulated disorder with vanadium concentration for Fe/MgO/$Fe_{1-x}V_x$ MTJs [1].

Finally, it is interesting to mention that, in the opposite to what could be expected from the previous reports observed the strong excess of the magnetic noise to be correlated with the bias dependence of TMR [2] pointing on the spin polarised electrons as a main source of the 1/f noise, in our experiment find an *increase of the TMR* value due to the Vanadium doping accompanied by *a strong decrease of the magnetic noise* (Hooge in antiparallel state) (Fig. 2). This might indicate on the defects in the barrier as one of the sources of magnetic contribution to the 1/f noise.

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References:

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[2] F.G. Aliev, R. Guerrero, D. Herranz, R. Villar, F. Greullet, C. Tiusan and M. Hehn , Appl. Physics Letters **91**, (2007), 232504.

Figures:

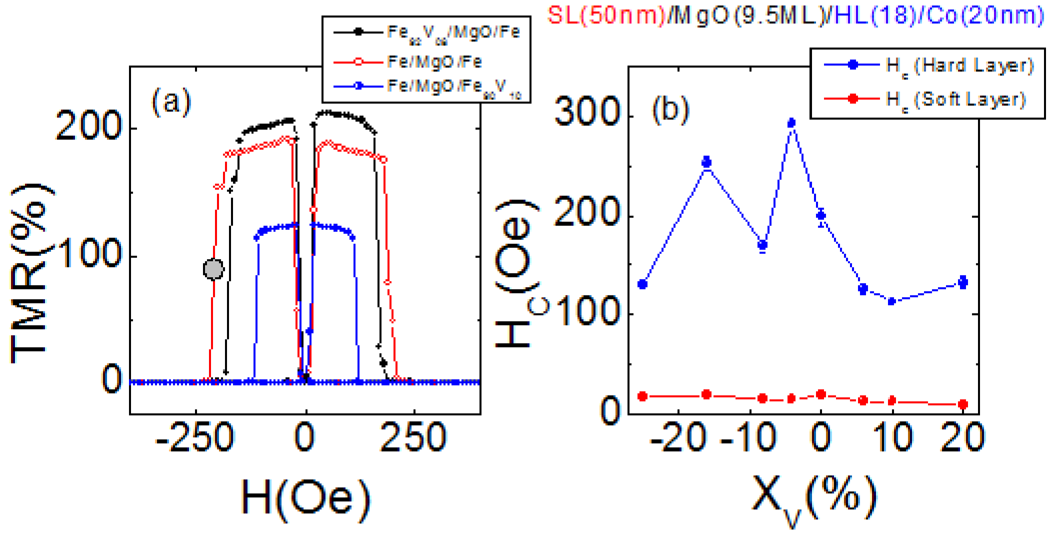

Figure 1 (a) Representative zero bias magnetoresistance for $Fe_{0.92}V_{0.08}$MgO/Fe (bottom electrode doped), Fe/MgO/Fe (non doped) and Fe/MgO/$Fe_{0.9}V_{0.1}$ MTJs. (top electrode doped).(b) Averaged over samples coercive (switching as marked by gray dot) fields of the hard (upper) and soft (bottom) layers as a function of Vanadium concentration. Negative x values correspond to bottom, while positive to the upper electrode Vanadium concentration.

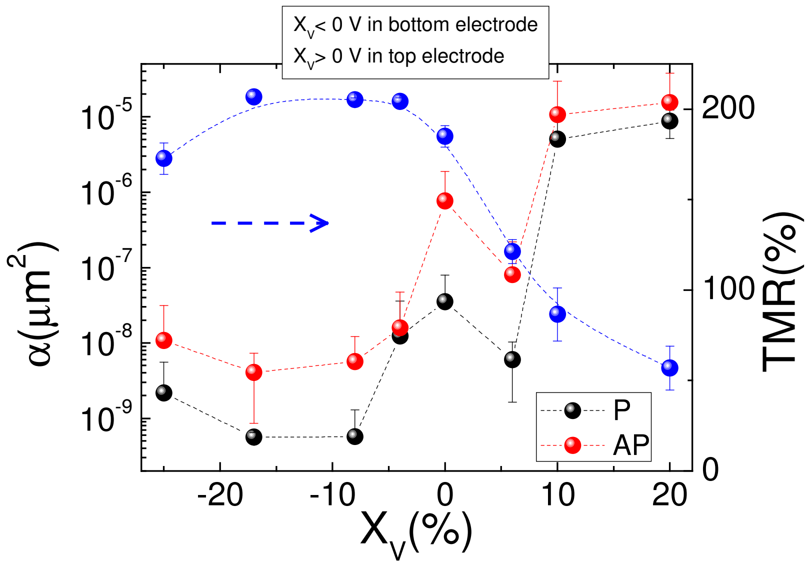

Figure 2: It is shown the variation of the averaged within each set of samples TMR and normalized 1/f noise (Hooge parameter) with V substitution of bottom (negative x values) and upper (positive x values) electrodes.