CONDUCTANCE AND NOISE IN FULLY EPITAXIAL Fe/MgO/Fe MAGNETIC TUNNEL JUNCTIONS

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Magnetic tunnel junctions (MTJs) are nowadays one of the most active areas of material science and spintronics. Here we review our recent studies of conductance and noise as a function of applied bias and magnetic state in different types of MTJs. Such combined measurements have recently demonstrated to be a powerful tool to understand and optimise electron tunnelling processes in polycrystalline (with Al_2O_3 barrier) and in fully epitaxial (with MgO barrier) magnetic tunnel junctions devices with room temperature Tunnelling Magneto-Resistance (RT-TMR) exceeding 100% [1-3]. We shall compare the data on the control Fe/MgO(001)/Fe MTJs and one obtained for the MTJs with carbon-doped bottom Fe/MgO interface. Such doping was previously shown to lead to strongly asymmetric TMR vs. bias, providing a root for creation of high-output voltage device applications [4].

The experimental on the shot noise clearly indicate the absence of electron correlations and/or sequential tunnelling phenomena for negative bias when the electrons are injected from the top Fe/MgO towards the bottom Fe-Fe-C/MgO interface in carbon doped MTJs. When electrons are injected from bottom to upper electrodes, the shot noise also shows the Fano factors close to 1, except the narrow region close to 0.5V when some resonant tunnelling (presumably through asymmetrically situated oxygen vacancies) suppresses weakly (Fano decreases to about 0.9) the shot noise. In general, the data on the shot noise proves that both parallel (P) and anti-parallel (AP) spin-dependent conductance are due to pure (direct) tunnelling between electron bands. The high MTJs quality and coherent tunnelling is further confirmed by the large breakdown voltage of the MTJs (up to 3 V) [2].

Low frequency noise analysis performed on our fully epitaxial MTJs show extremely low 1/f noise levels [3]. We have found that the normalized noise (Hooge factor) asymmetry between parallel and antiparallel states may strongly depend on the applied bias and its polarity. Fully epitaxial Fe/C/MgO/Fe(001) MTJs exhibit record low Hooge factors being at least one order of magnitude smaller than previously reported.

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