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Modeling of the switching process in multi-layered magnetic tunnel junctions

A. Makarov, V. Sverdlov, D. Osintsev, and S. Selberherr
Institute for Microelectronics, Technische Universität Wien, Austria
E-mail:makarov@iue.tuwien.ac.at

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The theoretical predictions [1] and the experiments [2, 3] of spin transfer switching demonstrated that the spin transfer torque random access memory (STTRAM) is one of the promising candidates for future universal memory. The reduction of the current density required for switching and the increase of the switching speed are the most important challenges in this area. In this work we investigate the dynamics of the switching process in a magnetic tunnel junction composed of 5 layers, namely Py(20nm)/Cu(12nm)/Py(4.5nm)/AlO_x(2nm)/Py(8nm), where Py is $Ni_{81}Fe_{19}$. The in-plane cross-section of the tunnel junction is elliptical with 40nm length of the minor axes and aspect ratio of 3:1. We performed micromagnetic simulations of the switching process by including the spin transfer torque in the Landau-Lifshitz-Gilbert equation (Fig.1). For the purpose of comparison, we also investigated a 3 layer MTJ Py(4.5nm)/AlO_x(2nm)/Py(8nm). We observed a reduction of the switching time in the 5 layer MTJ with anti-parallel magnetization of the fixed layers as compared to the corresponding 3 layer MTJ. In contrast, the switching time increased for parallel magnetization of the fixed layers. This is in agreement with measurements from [3]. We also studied the dependence of the switching time from the Gilbert damping parameter for the 5 layer MTJ with anti-parallel magnetization of the fixed layers (Fig. 2). Simulations confirm a possibility to manufacture STTRAM cells with a switching time less than 1.5 ns.

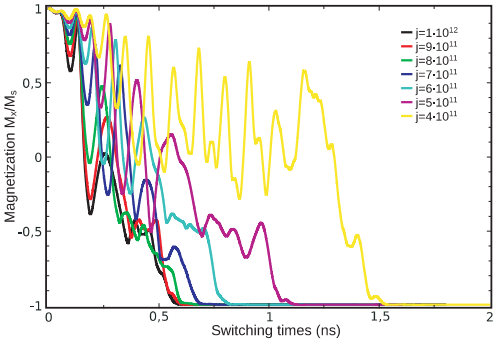

Fig. 1: Dynamics of magnetization during switching for P→AP processes and α=0.01.

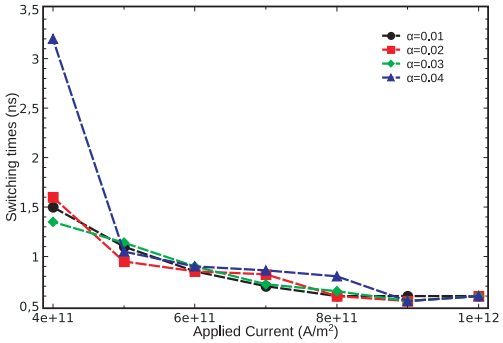

Fig. 2: Switching time as function of current for P→AP processes for different damping values.

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