Voltage and current-driven dynamics of magnetic tunnel junctions

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Magnetic tunnel junctions (MTJs) are one of the most important spintronic structures due to their broad spectrum of applications, including: magnetic random access memories (MRAMs), spin-torque-oscillators (STOs), hard disk drive read heads and spin-diode radio frequency detectors. Thanks to the electric current and voltage control of the magnetization, all of the mentioned devices are being developed and brought closer to the industrial implementation. This process is significantly enhanced and sped up by using modelling and simulation techniques.

In this work, a comprehensive micromagnetic description of MTJs will be shown. Research on modelling of current and voltage excitation for both switching operations as well as generation and detection of AC signals will be shown. We will introduce a model of local resistance calculations which is used by us to obtain a realistic inhomogeneous current distribution in MTJ [1]. Our recent research on backhopping [2] in MRAM and inhomogeneous magnetic field influence on STO [3] will be presented. The MTJ description will be completed with an examination of surface anisotropy influence on magnetic disorder in voltage driven dynamics [4] (see fig. 1).

The discussion will be augmented by description of simulation enhancement tools [5] as well as by comparison with our experimental results [6].

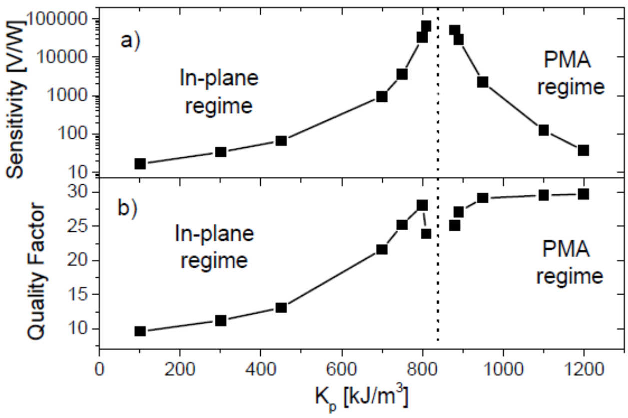

Figure 1. Sensitivity and quality factor dependence on the anisotropy energy in MTJ. Please note the abrupt changes near in-plane – out-of-plane transition originating in disorder which is modelled in our micromagnetic approach.

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