Analysis of stability diagram of perpendicular magnetic tunnel junctions

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Magnetic tunnel junctions (MTJs) have become a basic building blocks of contemporary spintronics devices, such as spin transfer torque magnetic random access memory (STT-MRAM) cells, microwave generators and detectors [1]. Various properties of such devices can be improved by using ferromagnetic materials with perpendicular magnetic anisotropy [2].

We present a study on such perpendicular MTJs with a composite CoFeB/W/CoFeB free layer (FL) of different thickness and Co-Pt-superlattice-pinned CoFeB reference layer, deposited using Singulus Timaris sputtering system, which reveal up to 180 % of tunneling magnetoresistance (TMR) ratio and perpendicular anisotropy field of up to 450 kA/m. The effective magnetic damping (α) parameter was determined using vector network analyzer ferromagnetic resonance method and increased from 0.038 up to 0.087 with increasing FL thickness, which coincides with a decrease of effective magnetization from 450 to 15 kA/m, the latter value being close to an in-plane magnetization orientation.

Voltage vs. perpendicular magnetic field switching diagrams were measured in MTJs patterned into 130 nm diameter nanopillars with different thickness of the FL. An extension of model presented in Ref. [4] was proposed, taking into account not only STT but also voltage control of magnetic anisotropy (VCMA) an thermal effects. For the thinnest FL (t_{FL} = 1.1 nm), which manifest the smallest α and the highest effective magnetization, we obtained damping-like STT coefficient τ_{DL}=4.5e-19 Nm and VCMA of κ = 46 fJ/Vm. The VCMA coefficient increases, whereas τ_{DL} remains almost constant, for MTJs' FL thickness FL [5].

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