Impact of Spin-Flip Length in dsMTJ Spacer Layers on Switching Performance

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We investigate the switching performance of Mo/CoFeB double spin-torque magnetic tunnel junctions depending on the spin-flip length of the non-magnetic spacer layer (SL). Mo-based perpendicular magnetic tunnel junctions (Mo-pMTJs) have demonstrated ultrafast sub-ns switching at low temperatures, making them a potential option for future memory applications [1]. Adding an additional pinned layer (PL) and a non-magnetic SL leads to additional torque experienced by the free layer, leading these structures to be termed double-spin torques MTJs (dsMTJs). dsMTJs have shown promising results in reducing the switching current and cell size [2]. We used a Finite-Element-Method (FEM) micromagnetic framework to evaluate the spin torques produced in bulk as well as at interfaces [3] in multilayered structures which include ferromagnetic layers separated by tunnel barriers and non-magnetic SLs.

We have used [1] to extract material parameters of Mo and CoFeB, and the spin drift-diffusion transport model parameters (e.g. spin-flip, spin dephasing and exchange lengths) for CoFeB have been taken from [4] [5]. We assumed a 1nm normal SL between the free layer and the second PL in the dsMTJ. Fig.1a shows the spin torques acting on different layers of the dsMTJ, demonstrating the impact of the spin-flip length in the SL on the torque. The additional PL in the dsMTJ contributes an additional torque acting on the free-layer, resulting in the second peak of the torque (Fig.1a), at the FL-SL interface. The increased spin torque in dsMTJ structures leads to increased switching performance in comparison to pMTJ structures with only one RL. The amount of additional spin torque in dsMTJ highly depends on the spin-flip length inside the SL shown in Fig.1b making materials with large spin-flip lengths, like Ruthenium with a spin-flip length of 1.9 nm, more favorable. dsMTJs with a SL with a large spin-flip length show decreased critical switching currents and therefore improved switching performance.

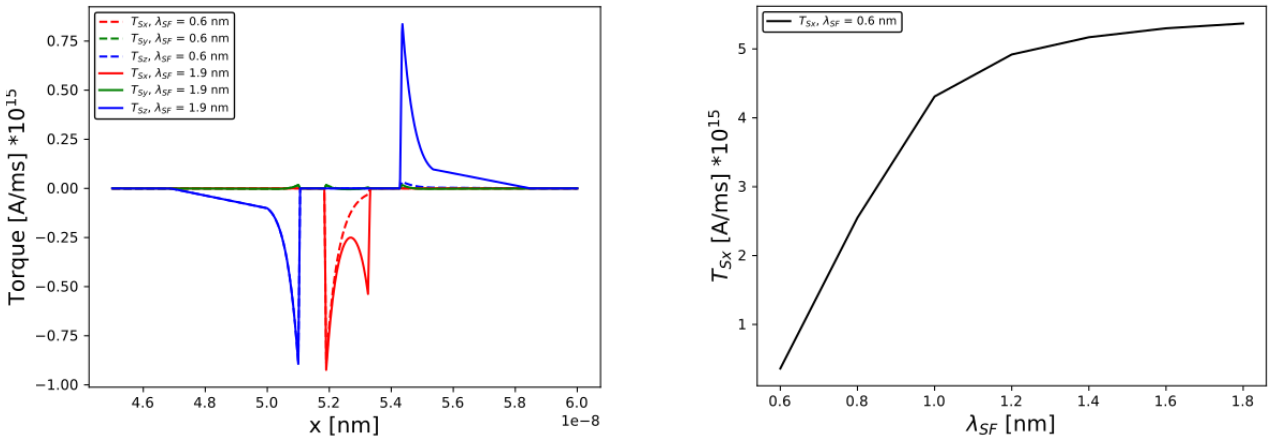

Figure 1: (a) Spin torques acting on a dsMTJ structure for different spin-flip lengths. (b) Dependence of the spin torque acting on the free layer on the spin-flip length of the nonmagnetic spacer.

References

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