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Spintronics XI

Sunday - Thursday 24 - 28 August 2020

Session 6A: Spin Transfer Torque

Monday 24 August 2020
Session Chair: Igor Žutic, Univ. at Buffalo (United States)

Single-shot dynamics of spin-orbit torque and spin transfer torque switching in three-terminal magnetic tunnel junctions *(Invited Paper)*

Paper 11470-42
Author(s): Viola Krizakova, Eva Grimaldi, Giacomo Sala, ETH Zurich (Switzerland); Farrukh Yasin, Sébastien Couet, Gouri Sankar Kar, Kevin Garello, imec (Belgium); Pietro Gambardella, ETH Zurich (Switzerland)

Current-induced torques enable fast and efficient control of the state of magnetic tunnel junctions (MTJ). While switching dynamics has been extensively studied in spin transfer torque (STT) driven MTJ devices, less is known about the transient dynamics and actual reversal speed of individual switching events induced by spin-orbit torques (SOT). Our real-time single-shot measurements reveal that SOT switching unfolds by a stochastic two-step process involving the nucleation and propagation of a reversed domain. Timescales and statistical distributions of these processes differ significantly when compared to switching by STT. The stochastic nature of the switching dynamics can be minimized by the combined action of SOT, STT, and the voltage control of magnetic anisotropy, resulting in reproducible sub-nanosecond switching with a distribution of switching onsets and durations approaching 0.1 ns.

Current-induced torques generated by metal oxides *(Invited Paper)*

Paper 11470-43
Author(s): Kazuya Ando, Keio Univ. (Japan)

We show that the current-induced torque generated can be significantly enhanced by the oxidation of metals. The oxidation allows efficient generation of the current-induced torques using Cu, a light metal with weak spin-orbit coupling [1]. We also show that the torque efficiency of ferromagnetic-metal/Cu-oxide bilayers can be maximized by a fine tuning of the oxidation level of the Cu layer [2]. The origin of the maximization is attributed to the enhancement of the interface spin-orbit coupling, showing that the bulk spin-orbit coupling of the oxidized Cu layer plays a minor role in the generation of the torque generation by naturally oxidized Cu. [1] H. An, Y. Kageyama, Y. Kanno, N. Enishi and K. Ando, Nature Communications 7, 13069 (2016). [2] Y. Kageyama, Y. Tazaki, H. An, T. Harumoto, T. Gao, J. Shi, and K. Ando, Science Advances 5, eaax4278 (2019).

Comprehensive modeling of coupled spin-charge transport and magnetization dynamics in STT-MRAM cells *(Invited Paper)*

Paper 11470-44
Author(s): Simone Fiorentini, Johannes Ender, Mohamed Mohamedou, Viktor Sverdlov, Technische Univ. Wien (Austria); Wolfgang Goes, SILVACO Europe Ltd. (United Kingdom); Roberto Orio, Siegfried Selberherr, Technische Univ. Wien (Austria)

We employ a finite element discretization scheme to solve numerically the coupled magnetization dynamics' and spin-charge transport equations in STT-MRAM cells. The demagnetizing field is computed using a coupled finite element-boundary element method. To evaluate the spin and charge transport, we model the tunnel barrier as a material with a low magnetization-dependent conductivity and a large spin diffusion constant. The generalized spin-charge drift-diffusion approach is applied to determine the torques entering the Landau-Lifshitz-Gilbert equation to describe the magnetization dynamics. In particular, the switching times under a fixed voltage, a fixed current, and a fixed current density are compared.