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Spintronics XI

Sunday - Thursday 11 - 15 August 2019

Session 15B: Devices and Sensors I

Thursday 15 August 2019
8:00 AM – 10:00 AM
Session Chair: Hubert Brückl, Donau-Univ. Krems (Austria)

All-in-one spin Hall magnetic sensor *(Invited Paper)*

Paper 11090-122
Time: 8:00 AM - 8:30 AM
Author(s): Yihong Wu, Yanjun Xu, Yumeng Yang, Mengzhen Zhang, National Univ. of Singapore (Singapore)

Commercial AMR, GMR and TMR sensors require an appropriate magnetic bias for both output linearization and noise suppression, resulting in increased structural complexity and manufacturing cost. Taking advantage of recently discovered spin-orbit torque and spin Hall magnetoresistance (SMR) in ferromagnet (FM) / heavy metal (HM) bilayers, we have demonstrated an all-in-one SMR sensor which embodies multiple functions of AC excitation, domain stabilization, rectification detection, and DC offset cancellation, and importantly, all these features are realized in a simplest possible structure which consists of only an ultrathin NiFe/Pt bilayer [1-3]. In this talk, I will discuss the mechanism for noise and offset reduction and demonstrate a few proof-of-concept applications of the SMR sensors. [1] Y.M. Yang et al., Appl. Phys. Lett. 111, 032402 (2017); [2] Y. J., Xu et al., J. Appl. Phys. 122, 193904 (2017); [3] Y.J. Xu et al., Adv. Mater. Technol., Adv. Mater. Tech. 3, 1800073(2018).

Magnetic field-free deterministic switching of a perpendicular magnetic layer by spin-orbit torques *(Invited Paper)*

Paper 11090-123
Time: 8:30 AM - 9:00 AM
Author(s): Roberto Orio, Siegfried Selberherr, Viktor Sverdlov, Technische Univ. Wien (Austria)

We demonstrate that fast (sub-500ps), deterministic, and magnetic field free switching of a perpendicularly magnetized recording layer is achieved by employing two orthogonal short (~100ps) current pulses running through the two heavy metal lines with a partial overlap with the free layer. The switching scheme is extremely robust with respect to pulse duration fluctuations and pulse synchronization failure as it yields a large confidence window for the time delay/overlap between the two pulses. The optimal overlap of the second pulse line with the free layer is found to be around 30-50%.

Design and fabrication of high performance spintronic sensors *(Invited Paper)*

Paper 11090-124
Time: 9:00 AM - 9:30 AM
Author(s): Weisheng Zhao, Beihang Univ. (China)

Magnetic sensors based on giant magnetoresistance (GMR) effect and tunneling magnetoresistance (TMR) effect have been widely explored over the past decades for many applications. In order to detect the precise direction of a magnetic field, multi-axis magnetic sensors are necessary. To form such sensors, a conventional technique is to mount two or three sensors with orthogonal sensing directions. However, the complexity and inaccuracy in alignment are the main drawbacks. In this talk, we will present a method for monolithic integration of in-plane two-axis GMR sensors, which enables an economic fabrication process. Then, we will introduce the design of perpendicular TMR sensors based on crossed magnetization pattern by combining an in-plane magnetized free layer and a perpendicularly magnetized reference layer.

Recent progress in the development of high-sensitivity tunneling magnetoresistive sensors *(Invited Paper)*

Paper 11090-125
Time: 9:30 AM - 10:00 AM
Author(s): Xiaolu Yin, Western Digital Corp. (United States); Yi Yang, University of Nebraska-Lincoln (United States), Nebraska Ctr. for Materials and Nanoscience (United States); Yen-Fu Liu, Nebraska Ctr. for Materials and Nanoscience (United States), Univ. of Nebraska-Lincoln (United States); Jiong Hua, Andrei Sokolov, Nebraska Ctr. for Materials and Nanoscience (United States); Dan Ewing, Paul J. De Rego, Department of Energy's National Security Campus (United States); Kaizhong Gao, International Business and Technology Service Corporation (United States); Sy-Hwang Liou, Univ. of Nebraska-Lincoln (United States), Nebraska Ctr. for Materials and Nanoscience (United States)

The development of high-sensitivity magnetic field sensors at low frequencies and ambient temperatures is of great importance for many practical applications, where different aspects of the sensor performance need to be considered. In this paper, it is presented that by tuning magnetic nanostructures of the free layers in magnetic tunnel junctions, wide-dynamic-range or ultra-high-sensitivity tunneling magnetoresistive sensors can be obtained. Tunneling magnetoresistive sensors with a linear response from -75 mT to +75 mT are demonstrated. Also, it is demonstrated that an optimized ultra-high-sensitivity magnetic sensor with a sensitivity of 57,790 %/mT can be achieved. This sensitivity is currently the highest among all magnetoresistive sensors that have been reported. The estimated noise of our magnetic sensor is 2.3 pT/Hz1/2 at 1 Hz and 190 fT/Hz1/2 at 100 Hz respectively. This tunneling magnetoresistive sensor dissipates only 25 μW of power operating under applied voltage of 1 V.