Second Laureate
Fundamental Research

Project Title: Spintronics microwave nano-oscillator with anisotropic materials

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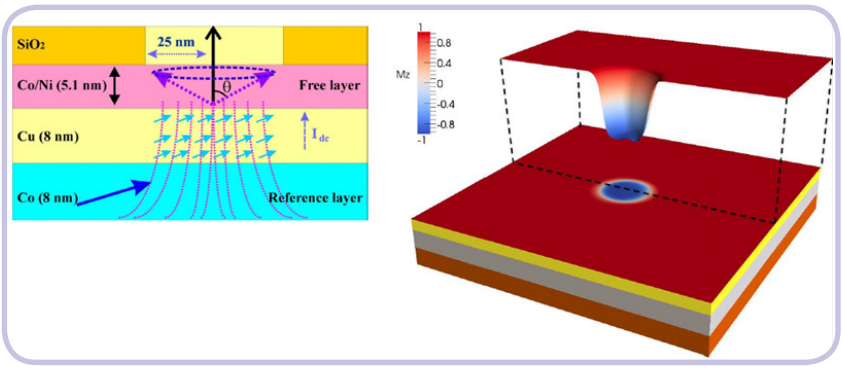
Abstract:

Spin-transfer-torque (STT) is established in a three layers spin valve (left figure) made of two magnetic layers separated via a metallic/insulator spacer. While a high current crosses over the structure, a spin polarized current from one magnetic layer (reference layer) passes though the spacer and impinges on another magnetic layer (free layer) and then changes the resistance of the whole structure, causes an unstable equilibrium between damping and STT resulting in precession of the free layer and finally revealing a time variable voltage with nanosecond rate. Finally, this device is able to transfer dc current to ac voltage, with sub-micron size, is able to be integrated in microelectronics beside other semiconductors, has a wide band frequency operation tunable with current and magnetic field. In this application, results of spin-torque oscillator (STO) fabricated with high perpendicular magnetic anisotropy from ultrathin Co and Ni multilayers (as free layer) are presented. We first achieved an STO with high frequency output (12 GHz at 0 T and 40 GHz at 1 T), tunable with current and magnetic field. As featured scientific achievement, dynamical magnetic droplet as a spintronics soliton objet (right figure) is observed. Such droplet soliton was already predicted in 1977 with Russian scientists, and however, with high amount of scientific reports after the first prediction, it has yet remained demanding for experimental evidence. Our observations and measurements reflect nonlinear dynamical droplet including, periodical droplet un-centering and droplet deformation and droplet spinning. Such droplet can produce field and current frequency shifter; and is able to increase the output power of STOs, shows step resistant changes, all new in nonlinear physics, spintroics, and also opened new horizon in observable mathematical object for future studies.



Right: The middle region (from simulation) of the above spin valve shows droplet soliton, with magnetization against the environmental region and precessing around the boundary. Left: three layers spin valve.