Geometry Optimization of Spin-Torque Oscillators Composed of Two MgO-MTJs with a Shared Free Layer

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New types of spintronics devices utilizing all-electrical magnetization manipulation by current, such as spin-torque transfer RAM and spin-torque oscillators, have been developed based on MgO magnetic tunnel junctions (MTJs) with a large magneto-resistance ratio [1]. Spin-torque oscillators based on a single MTJ with in-plane magnetization [2] show high frequency capabilities, but still need an external biasing magnetic field and are characterized by low output power level [3]. Oscillators on MTJs with perpendicular magnetization [4] and vortex-based oscillators [5] are shown to generate oscillations without external magnetic field, however, their low operating frequencies, usually below 2GHz, limit their functionality and application as a tunable oscillator [3]. In [6] we proposed a biasing field-free spin-torque oscillator based on an in-plane MgO-MTJ with an elliptical cross-section but not perfect overlap between the free layer and the fixed magnetic layers. However, a disadvantage of such an architecture is a narrow range of frequencies and their weak dependence on the current density. In [7] we proposed a novel design of spin-torque oscillators composed of two MgO-MTJs with in-plane magnetization, which operate without biasing magnetic field (Fig.1). In this work we present a geometry optimization of a spin-torque oscillator composed of two MgO-MTJs with a shared free layer by means of extensive micromagnetic simulations. We show that such structure is characterized by a wide variability of high oscillating frequencies from a few GHz to several ten GHz. Our simulations demonstrated that a decrease of the distance *c* between the MTJ_A and MTJ_B, a decrease of the short axis *b* and long axis *a* of MTJ_B, and an increase of the thicknesses of the free layer cause an increase of the frequency at the same current density. Fig. 2 shows the switching process in such an optimized structure in detail. We observed a rapid transition to a state of oscillation with high amplitude of the tunnel resistance. The Fourier transform of the signal is sharply peaked around the frequency of 12.4GHz. The dependence of the oscillation frequency on geometry and current density makes these structures attractive for high frequency applications.

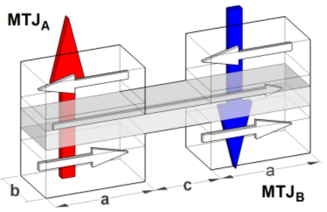

Fig. 1. Schematic illustration of a spin-torque oscillator composed of two MgO-MTJs. Colored arrows indicate the positive direction of the current for each of the MgO-MTJs.

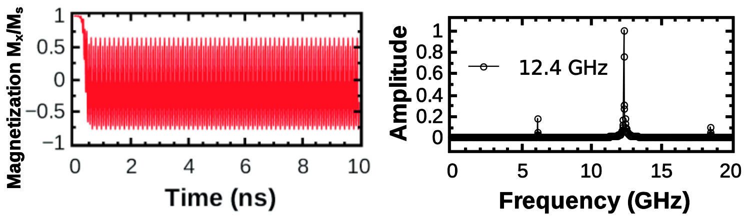

Fig. 2. (left) Magnetization components in MTJ_B as a function of time for a free layer of 45×10×1.25nm^2 (*c*=5); (right) Signal spectral density normalized to its maximum value. The current density through MTJ_A is $5\cdot10^8$A/cm^2 and $2\cdot10^7$A/cm^2 through MTJ_B. The peak of the amplitude is observed at a frequency of 12.4GHz.

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