TP56

Micromagnetic Modeling of a Bias-Field-Free Spin-Torque Oscillator Based on Two MgO-MTJs with a Shared Free Layer

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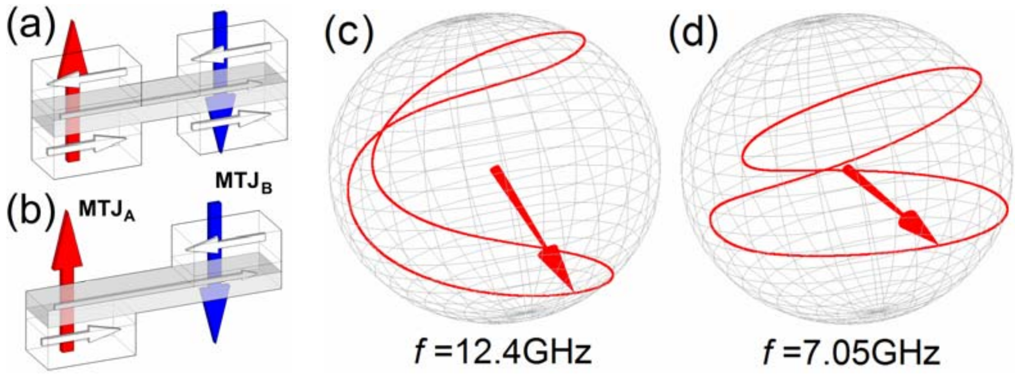
Spin-torque oscillators based on a single MTJ with in-plane magnetization exhibit high frequency capabilities, but still need an external biasing magnetic field and are characterized by low output power level [1]. Oscillators on MTJs with perpendicular magnetization and vortex-based oscillators are shown to generate oscillations without an external magnetic field, however, their low operating frequencies, usually below 2GHz, limit their functionality and application as tunable oscillators [1]. In [2] we proposed a novel design of spin-torque oscillators composed of two in-plane MgO-MTJs with a shared free layer, which show high frequency and operate without a biasing field (Fig.a). In this work we present a geometry optimization of such structures by means of extensive micromagnetic simulations. The results demonstrate that a decrease of the distance between MTJ_A and MTJ_B, a decrease of the long axis of MTJ_B, and an increase of the short axis and the thickness of the free layer cause an increase of the frequency at the same current density. The oscillation amplitude depends on the geometry in a manner inverse to that of the frequency, except the variation of the short axis and thicknesses of the free layer, which do not lead to noticeable changes. It is to note, that the variation of the long axis of MTJ_A does not lead to a change in the frequency and amplitude of the oscillations. Using these dependences we show that the structure of the free layer $45\times10\times1.25\text{nm}^3$ combines both, high frequency and large amplitude of oscillations (Fig.c). As can be seen in Fig.c, the cause of the high-frequency of oscillations in such structures is that during each cycle the magnetization passes twice through the magnetization states with opposite direction. In what follows, the oscillations in a system composed of two three-layer MgO-MTJs (Fig.b) are investigated. The structure based on two three-layer MgO-MTJs, as well as the structure based on two penta-layer MgO-MTJs, demonstrate stable oscillations (Fig.d). Despite the fact that the structure (b) shows a frequency lower than (a), the out-of-plane magnetization oscillation also decreases, which leads to an increase in output power.



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