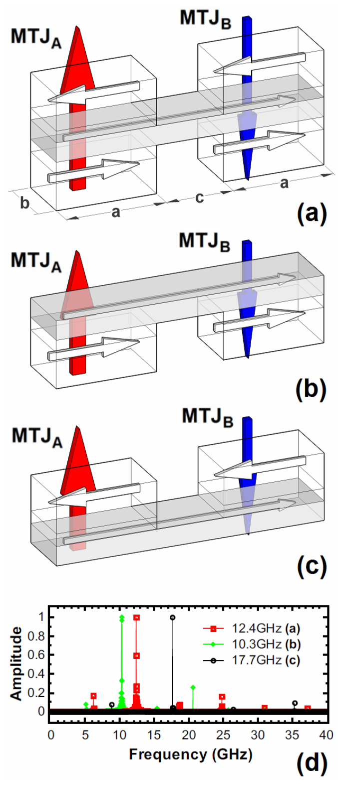
SIMULATION OF MAGNETIC OSCILLATIONS IN A SYSTEM OF TWO MTJS WITH A SHARED FREE LAYER

A. Makarov, V. Sverdlov, D. Osintsev, and S. Selberherr

Institute for Microelectronics, TU Wien, Gußhausstraße 27-29 / E360, 1040 Wien, Austria

Spin-torque oscillators based on a single MTJ with in-plane magnetization [1] exhibit high frequency capabilities, but still need an external biasing magnetic field and are characterized by low output power level [2]. Oscillators on MTJs with perpendicular magnetization [3] and vortex-based oscillators [4] are shown to generate oscillations without external magnetic field, however, their low operating frequencies, usually below 2GHz, limit their functionality and application as tunable oscillators [2]. In [5] we proposed a biasing magnetic 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 [6,7] we proposed a novel design of spin-torque oscillators composed of two penta-layer MgO-MTJs with in-plane magnetization, which operate without biasing field (Fig.a). In this work we investigate oscillations by means of extensive micromagnetic simulations in a system composed of two three-layer MgO-MTJs with a shared free layer.

Fig. b,c show the investigated structures. All the nanopillars used consist of CoFeB(1.25nm)/ MgO(1nm)/ CoFeB(5nm) MTJs, with fixed layers $20\times10\text{nm}^2$ ($a\times b$) and a free layer length of 45nm (c=5nm). Colored arrows indicate the positive direction of the current for each of the MgO-MTJs. Our analyses are based on the magnetization dynamics described by the Landau-Lifschitz-Gilbert-Slonczewski (LLGS) equation in the areas of current flow and the Landau-Lifschitz-Gilbert (LLG) equation otherwise [8]. The interaction between different areas occurs due to the magnetic exchange interaction and magnetostatic coupling. Structures (b) and (c), as well as (a), demonstrate stable oscillations. Fig. d shows the signal spectral density normalized to its maximum value. The current density through MTJ_A is $5\cdot10^8\text{A/cm}^2$ and $2\cdot10^7\text{A/cm}^2$ through MTJ_B. The peaks of the amplitude are observed at the frequencies of 12.4GHz [7], 10.3GHz, and 17.7GHz for structure (a), (b), and (c), respectively. Note that the structure (c) shows an oscillation frequency higher than the structures (a) and (b) at the same current densities. The reason is the in-plane magnetic field due to the pinned layers. In contrast to the penta-layer MTJ, where the magnetostatic field is compensated, in the three-layer MTJ structure this field tries to reverse the magnetization in the structure (b) or to stabilize it in the structure (c). This results in an increase (decrease) of the operation frequency in the structure (c) (structure(b)) as compared to the penta-layer structure (a), making these structures attractive for tuning their frequency without a biasing magnetic field.



[1] ZENG, Z *et al.*, Appl. Phys. Lett., **99**, (2011) 032503.
[2] SIM, C-H *et al.*, J. Appl. Phys., **111**, (2012) 07C914.
[3] ZENG, Z *et al.*, Sci. Rep., **3**, (2013) 1426.
[4] DUSSAUX, A *et al.*, Nature Comm., **1**, (2010) 8.
[5] MAKAROV, A *et al.*, Nano.: Phys. and Tech. (2013), accepted.
[6] MAKAROV, A *et al.*, SSDM (2013), submitted.
[7] MAKAROV, A *et al.*, ICNM (2013), submitted.
[8] MAKAROV, A *et al.*, Trans. on Magn., **48,** (2012) 1289.

Name and e-mail of corresponding author: A. Makarov
makarov@iue.tuwien.ac.at