Phase diagram of spin torque oscillator consisting of two free layers

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Microwave assisted magnetization reversal (MAMR) is a new scheme of magnetic recording, where the microwave emitted from a spin torque oscillator (STO) contributes to the reduction of the direct magnetic field necessary for the recording[1]. The latest design of the STO for MAMR consists of two in-plane magnetized ferromagnetic layers called field-generation layer and spin-injection layer[2]. An experimental effort investigating the magnetization dynamics excited in this type of STO has been reported recently[3]. One might consider that the field-generation layer plays a role of free layer in STO. It should be, however, noted that this type of STO does not include a pinned layer in order to make the recording head small for high density recording. Therefore, spin-transfer effect, as well as dipole interaction between two ferromagnets, excites magnetization dynamics not only in the field-generation layer but also in the spin-injection layer. Magnetization dynamics possibly occurring in this STO is, however, not fully understood yet.

In this work, a theoretical study investigating a phase diagram of the magnetization dynamics in this type of STO has been made by solving the Landau-Lifshitz-Gilbert (LLG) equation numerically[4]. Figures 1(a) and 1(b) summarize the dynamical phase of the STO in the presence of small and large perpendicular magnetic fields, respectively. It is clarified that, in both cases, the dynamical phase is classified into three regions. In the small current region, the magnetizations in the field-generation and spin-injection layers show a phase synchronization. On the other hand, in the middle current region, two magnetizations oscillate with different frequencies. In the large current region, the magnetization dynamics becomes chaos. The detail of the calculation will be presented at talk.

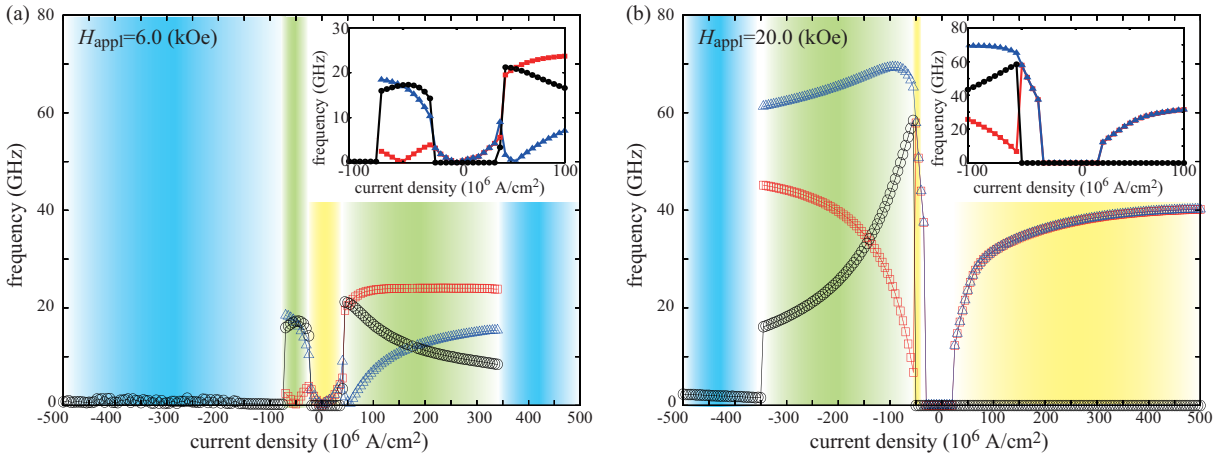

Figure 1: Current dependences of oscillation frequencies of magnetizations in the field-generation (red square) and spin-injection (blue triangle) in the presence of (a) small and (b) large perpendicular magnetic fields, respectively. The oscillation frequency of magnetoresistance is also shown (black circle).

1. J.-G. Zhu *et al.*, IEEE Trans. Magn. **44**, 125 (2008).
2. J.-G. Zhu, Joint MMM-Intermag Conference, San Diego, CA, USA, Jan. 2016, AB-11.
3. W. Zhou *et al.*, Appl. Phys. Lett. **114**, 172403 (2019).
4. T. Taniguchi, J. Magn. Magn. Mater. **483**, 281 (2019).