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Characterization of spin-torque oscillator with perpendicular magnetic anisotropy in the free layer under arbitrary bias field directions

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Spin-torque oscillators (STOs) are attracting significant attention as the next generation microwave devices. One of the challenges STOs are facing is the accomplishment of high quality factor (Q factor) and stable oscillation behavior. In general, STOs with an in-plane free layer magnetization tend to show a low Q factor, multiple oscillation peaks and random mode hopping, which are considered to be caused by instabilities of edge domains and patterning irregularities. In order to circumvent these difficulties, it is desirable for the free layer to have perpendicular magnetic anisotropy (PMA) because the out-of-plane magnetization is immune to edge domains and effects of patterning irregularities, thus expected to lead to a high Q-factor. Since the free layer magnetization precesses around the out-of-plane axis, the reference layer should have an in-plane magnetization to give a large output. We have already fabricated such devices (referred to as PMA-STO in the following) and obtained quite promising results [1].

Because our PMA-STOs have an in-plane reference layer magnetization which breaks the axial symmetry, its oscillation behavior may show some kind of dependence on the bias field direction to reflect the broken symmetry. For this reason, we measured the oscillation of a PMA-STO under arbitrary bias field directions. A PMA-STO is placed in a magnetic field of 200 mT, and both the polar angle θ and azimuth angle φ are rotated. The frequency and peak power as a function of φ for different θ are plotted in Fig. 1. The result shows that tilting of θ by as small as 4° already starts to cause uni-directional variation as φ is rotated, and the oscillation almost vanishes when θ and φ are set at 8° and near 90°, respectively, indicating that the small in-plane component of the free layer magnetization has significant impact on the oscillation behavior.

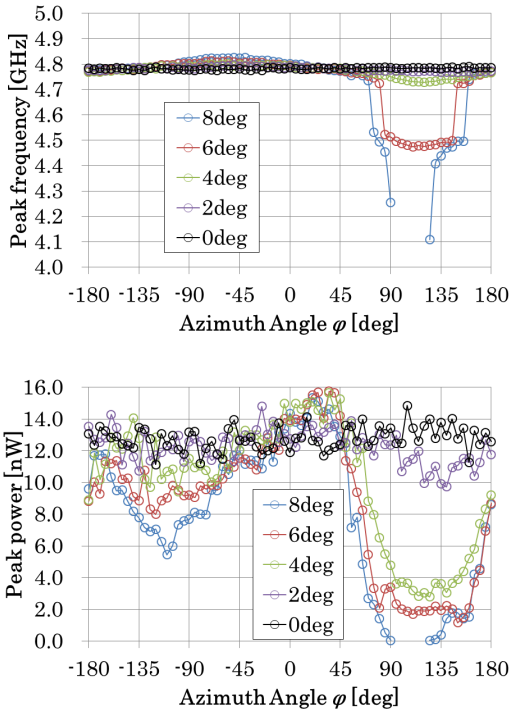

Fig. 1 Peak frequency and power of a PMA-STO as a function of φ for different θ.

[1] H. Kubota et al. : The JSAP Fall meeting 11P-PA2-2 (2012)

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