Electrical mutual synchronization in vortex spin torque oscillators

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Self-oscillation of the magnetization in a spin torque oscillator (STO) has been extensively studied with the aim of being applied in practical device such as nano size high frequency generator. The emission power of STOs in the early stage was a few pW, which was enhanced up to a few μW by using MgO-based magnetic tunnel junctions.[1,2] For the further purpose to increase emission power, applying synchronized STO array system was proposed as one of the possible candidates.[3] In the STO array, it is necessary to synchronize the phase of STOs by using magnetic or electrical interaction. Because electrical coupling is non-local, it is more commonly used when compared with magnetic coupling method. In this work, we report the results obtained for electrical mutual synchronization of vortex-STO and the improvement achieved in emission power.

We prepared three circular shaped STOs having the structure of sub/buffer/PtMn(15)/CoFe(2.5)/Ru(0.98)/CoFeB(2.5)/MgO(1)/FeB(4.0)/MgO(1)/Ta/Ru with 300 nm ϕ. The rf signals were generated by applying dc current I_{ch} and perpendicular field H_{perp}=3.50 kOe. The rf power of STO_A, STO_B and STO_C were 1.0 μW, 0.67 μW and 0.74 μW, respectively. Fig.1 shows the measurement setup for the mutual synchronization of two STOs. Two bias-tees were used to control the frequency individually. Tunable delay line was inserted in the circuit to control the phase difference between the STOs.[4] Fig. 2 shows the results of rf power depending on the number of STOs connected in the array. The rf power increases by increasing the number. This result evidently shows the achievement obtained by mutual synchronization and is the first report of emission-power enhancement using electrical mutual synchronization.

<Reference>

1) H. Maehara, et. al., APEX 6, 113005 (2013)
2) S. Tsunegi, et al. APEX 7, 063009 (2014)
3) B. Georges, et. al., Appl. Phys. Lett. 92, 232504 (2008)
4) A. Slavin, et. al., IEEE Trans. Mag. 45, 1875 (2009)

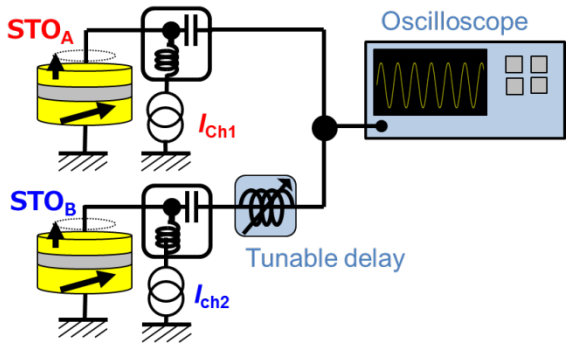

Fig. 1 Measurement set-up on mutual synchronization of two STOs.

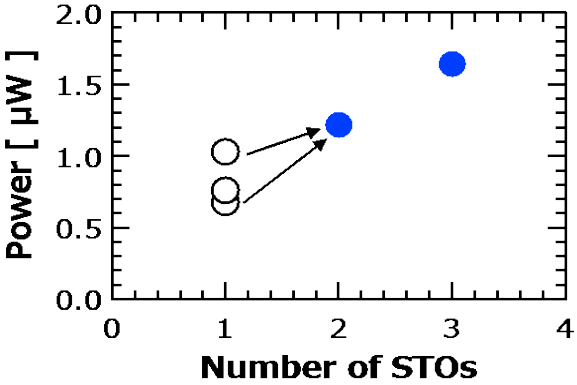

Fig. 2. Results of rf power depending on the number of STOs connected in the array. We used STO_A and STO_B for the two STO case.