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Microwave Generation in Triple-Point-Contact Spin-Transfer Oscillator

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The spin-transfer torque results from the interaction between the spin-polarized current and the local magnetization [1]. Rippard et al. [2] reported that spin-transfer devices can be used to generate steady-state precession of the magnetization in spin valves with dc electrical current. The precession frequency can be tuned over several gigahertz ranges by varying the applied current. The microwave power of a single spin torque nano-oscillator (STNO) is less than 1nW [3]. To achieve a higher power of the order of microwatts, the two-dimensional arrays of phase coherent emission system were proposed [3]. They reported phase-locking-that is, they synchronize in double-point-contact STNO. Power output of double-point-contact STNO is about 10 times bigger than that of two single-point-contacts STNO.

Here we performed micromagnetic simulation on how STNO works in a multi-point-contact system. The STNO has three 40-nm-diameter point contacts A, B and C separated by 100~150nm and each contact is separately current biased. Measurements are taken with the device placed in an external 740-mT magnetic field oriented 75° from the film plane. Fig. 1 shows the power spectral density (PSD) obtained at each STNO. PSDs at each STNO are almost identical when a regular triangular shaped array of three contacts is assumed. However, PSD at the contact C is much enhanced but those at the contact A and B are reduced when a right triangular shaped array of three contacts is assumed. Furthermore, the phase-locked frequency of the right triangular array is lower than that of the regular triangular one. It is because of difference in the spin-wave interactions. In the presentation, we will discuss more details about the spin-wave interactions as a function of array design.

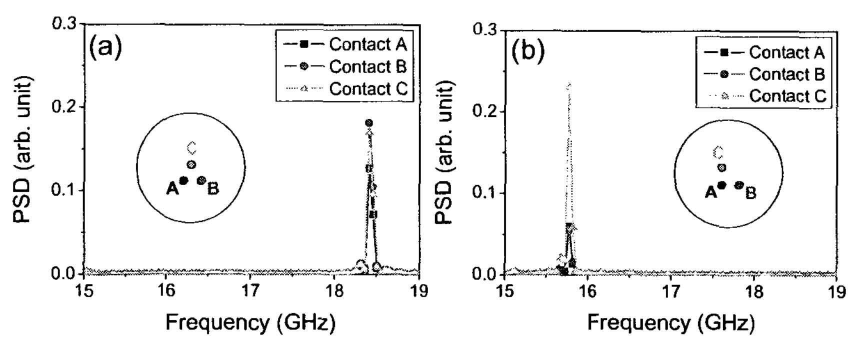

Fig. 1. Spectra of power spectral density of (a) regular triangle array of triple-STNO, and (b) right triangle array of triple-STNO ($J_A=J_B=J_C=6\times10^8 A/cm^2$).

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The Temperature of Magnetic Tunnelling Junction Nano-Pillar for Spin Transfer Torque

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We investigate the temperature of the magnetic tunnelling junction (MJJ) nano-pillar by finite element method for the spin transfer torque (STT). The STT is a novel writing mechanism, which can overcome the selectivity problems in the conventional magnetoresistive random access memory (MRAM). However, the switching current density is as large as 10^{10} A/m^2. The Joule heating by such huge writing current must be carefully considered for the reliability of the devices. Furthermore, the spin dynamics of the STT depends on the temperature of the system, the information of the temperature is important for the correct interpretation of the experimental data.

We take realistic parameters from the published data [1] for the calculation. The 100 nm×150 nm magnetic tunnelling junction structures are examined with the current density of 10^{10} A/m^2 with 2 ns pulse duration. Surprisingly, the increment of the temperature of nano-pillar is not serious, order of 1 K, as shown in Fig. 1 for the typical sample structures. We will discuss about the validity and physical meaning of the unexpected results.

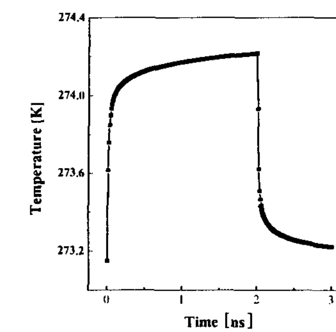

Fig. 1. Typical behavior of the temperature of the nano-pillar as a function of the time

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