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Thermal creation of stronger spin-transfer torque in oscillators and memories

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Oscillators and magnetic random-access memories (MRAMs) investigated today rely on spin-transfer torque (STT) carried by an electric current flowing through a magnetic tunnel junction (MTJ) having barrier composition MgO.[1] Experiments confirm the theoretical upper bound τ_e=1/2 on the torque yield (defined as dimensionless torque per unit supplied electric current). This bound limits the performance potential of STT-MRAM in which current supplied by one transistor within each cell switches the information bit. Replacement of electric current with heat flow (supplied by a Joule heater) carried by magnons may provide a greater torque yield τ_h.[2] The essential structure for this *thermagnonic* spin transfer (TMST) comprises a stack of three nano layers: a spontaneously magnetized insulator (*ferrite* for brevity), a non-magnetic metallic spacer, and the free metallic magnet responding to the transferred torque. Phonons carry most of the heat flowing through the ferrite. But spin-1 magnons also carry a portion of it and deposit pure spin polarization into the spacer whose free electrons transport it to the free magnet. Ferrite-metal interfaces also occur in a spin-Seebeck effect.[3] Principles of spin relaxation provide estimates of τ_h based on existing data for sd-exchange, superexchange, and non-magnetic interfacial thermal resistance; τ_h may exceed $\tau_e$by one order of magnitude.[4] Related results of an FMR spin-pumping experiment[5] and DFT computations[6] support the potential of TMST-MRAM. In the case of an oscillator, TMST could increase its efficiency and enable largely independent controls of frequency and output voltage.

[1]See the STT review by D. Ralph and M. Stiles, J. Magn. Magn. Mater. **320,** 1190 (2008).
[2]J. Slonczewski, Phys. Rev. B **82**, 054403 (2010).
[3]The talk by E. Saitoh in this Symposium
[4]J. Slonczewski, Phys. Rev. B **82**, 054403 (2010).
[5]B. Heinrich et al, Phys. Rev. Letts. **107**, 066604 (2011).
[6]The talk by K. Xia in this Symposium.