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Full control of the spin-wave damping in a magnetic insulator using spin orbit torque

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The spin-orbit interaction (SOI) has been an interesting and useful addition in the field of spintronics by opening it to non-metallic magnet. It capitalizes on adjoining a strong SOI normal metal next to a thin magnetic layer. The SOI converts a charge current, J_c, into a spin current, J_s, with an efficiency parametrized by Θ_{SH}, the spin Hall angle. An important benefit of the SOI is that J_c and J_s are linked through a cross-product, allowing a charge current flowing in-plane to produce a spin current flowing out-of-plane. Hence it enables the transfer of spin angular momentum to non-metallic materials and in particular to insulating oxides, which offer improved performance compared to their metallic counterparts. Among all oxides, Yttrium Iron Garnet (YIG) holds a special place for having the lowest known spin-wave (SW) damping factor. Until recently the transmission of spin current through the YIG—Pt interface has been subject to debate. While numerous experiments have reported that J_s produced by the excitation of ferromagnetic resonance (FMR) in YIG can cross efficiently the YIG—Pt interface and be converted into J_c in Pt through the inverse spin Hall effect (ISHE), most attempts to observe the reciprocal effect, where J_s produced in Pt by the direct spin Hall effect (SHE) is transferred to YIG, resulting in damping compensation, have failed. This has been raising fundamental questions about the reciprocity of the spin transparency of the interface between a metal and a magnetic insulator. In this talk it will be demonstrated that the threshold current for damping compensation can be reached in a 5 μm diameter YIG(20nm)—Pt(7nm) disk. Reduction of both the thickness and lateral size of a YIG-structure were key to reach the microwave generation threshold current, J_c^*. The experimental evidence rests upon the measurement of the ferromagnetic resonance linewidth as a function of I_{dc} using a magnetic resonance force microscope (MRFM). It is shwon that the magnetic losses of spin-wave modes existing in the magnetic insulator can be reduced or enhanced by at least a factor of five depending on the polarity and intensity of the in-plane dc current, I_{dc}. Complete compensation of the damping of the fundamental mode by spin-orbit torque is reached for a current density of $\sim 3 \cdot 10^{11}\mathrm{A.m}^{-2}$, in agreement with theoretical predictions. At this critical threshold the MRFM detects a small change of static magnetization, a behavior consistent with the onset of an auto-oscillation regime. This result opens up a new area of research on the electronic control of the damping of YIG-nanostructures.