Stack engineering of spin orbit torque efficiency in magnetic bilayers

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The simultaneous achievement of a larger spin-Hall angle and a lower magnetic damping is of importance to implement successful spin-orbit torque (SOT) devices. Recent works have proposed that the interface transparency of the spin current between a heavy metal and a ferromagnetic layer plays important roles in determining the effective magnitude of the spin-Hall angle; e.g. θ_{SH}(Pt|Co)~0.11 vs θ_{SH}(Pt|Py)~0.05 [1,2]. Unfortunately, the enhancement of spin-Hall angle with a higher spin transparency will be counteracted by the increase of the magnetic damping due to the spin pumping so that the variation of the transparency would not be much helpful; e.g. $\Delta\alpha_{sp}$(Pt|Co)~2・$\Delta\alpha_{sp}$(Pt|Py) [1,2].

For relieving this issue we utilized ferromagnetic bilayers instead of a single ferromagnetic layer on top of a Pt layer. We used DC/RF magnetron sputtering to deposit two series of multilayer films having different stack orders, Pt|Co|Py or Pt|Py|Co, on a thermally oxidized Si substrate at room temperature. The multilayers consist of, from the bottom to the top, Ta(1)/Pt(5)/Co(*t*)/Py(5-t)/MgO(2)/Ta(2) and Ta(1)/Pt(5)/Py(5-*t*)/Co(t)/MgO(2)/Ta(2) (thickness in nm) where the thickness of cobalt (t_{Co}) layer was varied from 0 to 5 nm.

We investigated spin-Hall angles and magnetic damping in ferromagnetic bilayers by utilizing the spin torque ferromagnetic resonance technique (ST-FMR) [3]. The properties (spin-Hall angle and magnetic damping) of ferromagnetic bilayers critically depend on the stacking order and bilayer thickness. We find that the spin-Hall angle is dominated by the ferromagnetic layer in contact to the Pt layer. On the other hand, the magnetic damping dominated by another factor, and the magnetic damping has exactly opposite dependence of spin-Hall angle.

In this presentation, we shall show the detailed results from our ST-FMR measurements for the various stacking order and thickness ranges, and will discuss possible damping mechanisms dependent on the stacking order and thickness.

References

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