# Current-induced magnetization switching using electrically-insulating spin-torque generator

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Current-induced magnetization switching through spin-orbit torques (SOTs) is the fundamental building block of spin-orbitronics. The SOTs generally arise from the spin-orbit coupling of heavy metals. However, even in a heterostructure where a metallic magnet is sandwiched by two different insulators, a nonzero current-induced SOT is expected because of the broken inversion symmetry; an electrical insulator can be a spin-torque generator.

Here, we demonstrate current-induced magnetization switching using an electrically-insulating spin-torque generator. We show that the widely used heavy metal, Pt, becomes an electrically-insulating generator of the spin-orbit torques after oxidation, enabling spin-torque magnetization switching in a heterostructure where a perpendicularly-magnetized ferrimagnetic metal (FM) is sandwiched by two insulating oxides: MgO and oxidized Pt. We found that even in the absence of any conducting heavy metals, the oxygen-incorporated Pt, attached to a metallic magnet, generates a robust damping-like spin-orbit torque purely through interface spin-orbit scattering, which counters the conventional understandings of the spin-orbit torques, where the origin of the damping-like torque is primarily attributed to the bulk SOC. We further show that the relative strength of the damping-like and field-like torques changes systematically depending on the oxidation level of the Pt layer. This allows electrical tuning of the spin-orbit torques through voltage-driven $O^{2-}$ migration near the FM/oxygen-incorporated-Pt interface. These results provide crucial piece of information for revealing the underlying physics behind the current-induced spin-orbit torques and open a route towards energy-efficient, voltage-programmable spin-orbit devices based on solid-state switching of heavy metal oxidation.