

Magnetization switching in α -W-based magnetic tunnel junction induced by a combination of spin-orbit and field torques

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Spin-orbit torque (SOT) devices typically rely on heavy metals with high spin Hall angles, often at the cost of high resistivity. In this work, we demonstrate efficient magnetization switching in magnetic tunnel junctions (MTJs) utilizing a low-resistivity α -W channel. W/FeCoB-based multilayers were sputter-deposited, with XRD and XRR analysis confirming the exclusive growth of the α -W(110) phase and high interface quality. The devices were patterned into Hall bars for harmonic analysis and nanopillars (up to 300×600 nm) on a $1 \mu\text{m}$ channel for switching experiments.

The α -W channel exhibited a low resistivity of $35\text{--}55 \mu\Omega\cdot\text{cm}$. Harmonic Hall measurements yielded spin Hall efficiencies of $\xi_{DL} \approx -0.047$ and $\xi_{FL} \approx -0.055$. Despite these moderate values compared to β -W, deterministic field-free switching was achieved at a current density of 1×10^{12} A/m². Macrospin simulations using the cmtj [1] solver reveal that this performance is driven by the constructive interplay between the field-like torque and the current-induced Oersted field [2]. The negative sign of the field-like torque prevents it from opposing the Oersted field, effectively lowering the switching threshold. These findings highlight α -W as a viable candidate for energy-efficient SOT-MRAM, where geometry optimization can compensate for lower intrinsic spin Hall efficiency.

References:

[1] J. Mojsiejuk et al., npj Comp. Mater., 9, 54 (2023).

[2] S. Fukami et al., Nat. Nanotechnol., 11, 621 (2016).

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