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Probing the Inverse Spin Hall Effect and Spin-Orbit Coupling in a Broad Range of Transition Metals by $Y_3Fe_5O_{12}$-Based Spin Pumping HAILONG WANG, CHUNHUI DU, P. CHRIS HAMMEL, FENGYUAN YANG, The Ohio State University — Spin-orbit coupling (SOC) is the underlying mechanism for spin Hall physics and it is generally believed that SOC follows Z^4 (atomic number) dependence and becomes significant only in heavy elements. We report FMR spin pumping from 20-nm $Y_3Fe_5O_{12}$ (YIG) films into a series of $3d$, $4d$, and $5d$ transition metals. We observe surprising large mV-level inverse spin Hall effect (ISHE) voltages in Pt, Ta, W, and Cr and robust ISHE signals in other metals. Using the ISHE voltages and damping enhancement, we determine the spin Hall angles and interfacial spin mixing conductances for these metals. Both $3d$ and $5d$ metals exhibit systematic behavior of the spin Hall angle, which reveals the critical role of d-electrons in SOC. Our result enriches the understanding of ISHE and broadens the scope of materials available for exploring the rich phenomena enabled by SOC as well as presenting a guidepost for testing theoretical models of SOC in transition metals.

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