Exchange Coupling with Exponential Decay in $Y_3Fe_5O_{12}$/Barrier/Pt Heterostructures$^1$

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Understanding the mechanism of spin pumping is essential for advancing this exciting field and realizing potential applications of pure spin currents. It is believed that exchange interaction between the ferromagnet and nonmagnetic material is responsible for this phenomenon. We have grown high-crystalline quality $Y_3Fe_5O_{12}$ epitaxial thin films by off-axis sputtering and observed millivolt level inverse spin Hall effect (ISHE) voltages in $Y_3Fe_5O_{12}$/Pt bilayer excited by an FMR cavity. By inserting an insulating barrier between $Y_3Fe_5O_{12}$ and Pt, we detect an exponential decay of the ISHE voltages over three orders of magnitude for four different barrier materials, including SrTiO$_3$, Sr$_2$GaTaO$_6$, Sr$_2$CrNbO$_6$, and Si. Exponential decay lengths of 0.16, 0.19, and 0.23 nm are extracted for Sr$_2$GaTaO$_6$, SrTiO$_3$, and Sr$_2$CrNbO$_6$ with band gaps of 2.36, 3.40, and 4.91 eV, respectively. The exponential dependence of spin pumping on barrier thicknesses can be explained by quantum tunneling of the conduction electrons in Pt through the barrier and coupling with the precessing magnetization of $Y_3Fe_5O_{12}$ through exchange interaction to acquire spin polarization.

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