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Spin Hall magnetoresistance in ferromagnetic insulator/normal metal hybrids

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Pure spin currents, i.e. the net flow of spin angular momentum without an accompanying charge current, represent a new paradigm for spin transport and spintronics. We have experimentally studied a new type of magnetoresistance effect, which arises from the interaction of charge and spin current flows in ferromagnetic insulator/normal metal hybrid structures. In more detail, we measured the resistance of yttrium iron garnet(YIG)/Pt, YIG/nonferromagnet/Pt, nickel ferrite/Pt, and magnetite/Pt hybrid structures as a function of the magnitude and the orientation of an external magnetic field. The resistance changes observed can be quantitatively traced back to the combined action of spin Hall and inverse spin Hall effect in the Pt metal layer, and are thus termed spin Hall magnetoresistance (SMR) [1, 2]. We show that the SMR is qualitatively different from the conventional anisotropic magnetoresistance effect arising in magnetic metals. From the magnetoresistance measurements in YIG/Au/Pt and YIG/Cu/Pt structures and from x-ray magnetic circular dichroism measurements on YIG/Pt heterostructures we exclude a static proximity magnetization in Pt as the origin of the magnetoresistance, in contrast to the mechanism proposed by Huang et al. [3]. Furthermore, the SMR enables us to quantify the spin Hall angle as a function of temperature in our Pt layers. In addition, we analyze the anomalous Hall type contribution of the SMR to quantify the imaginary part of the spin mixing conductance. Financial support by the DFG via SPP 1538 (project no. GO 944/4) and the Nanoinitiative Munich (NIM) is gratefully acknowledged.

[1] Nakayama et al., PRL, **110**, 206601 (2013)
[2] Althammer et al., PRB, **87**, 224401 (2013)
[3] Huang et al., PRL, **109**, 107204 (2012)