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Hybrid magnetoresistance in the proximity of a ferromagnet

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A new type of magnetoresistance (MR) effect has recently been observed in nominally nonmagnetic metal (Pt) thin films in contact with either a ferromagnetic (FM) insulator such as yttrium iron garnet (YIG),[1] or a FM metal,[2] such as permalloy (Py). The resistivities with in-plane magnetic fields parallel ($\rho_{\parallel}$) and transverse (ρ_{T}) to a current and a perpendicular field ($\rho_{\perp}$) at room temperature show the behavior of $\rho_{\perp} \approx \rho_{\parallel} > \rho_{\mathrm{T}}$, distinctively different from all other known MR effects, including the well-known anisotropic MR in FMs of $\rho_{\parallel} > \rho_{\mathrm{T}} \approx \rho_{\perp}$. The key question is whether the new MR is the proposed spin Hall MR (SMR) based on spin current conversion in Pt, or due to magnetic proximity effects (MPE), for which Pt is highly susceptible when in contact with a FM. Recent experiments show that the characteristics of $\rho_{\perp} \approx \rho_{\parallel} > \rho_{\mathrm{T}}$, for which the SMR theory accounts, do not hold at low temperatures nor at different magnetic fields. Furthermore, the new MR persists even after altering the Pt/YIG interface thereby blocking the spin current.[3] The feature of new MR can also be reproduced when Pt is in contact with a non-magnetic insulator doped with a few percent of Fe impurities. These results show that the new MR is probably due to both spin current and MPE. Through tuning the YIG surface and the insertion of other layers between Pt and YIG, we are able to separate the two contributions of spin current and MPE of the new hybrid MR. This work, in collaboration with S. Y. Huang, D. Qu (JHU) B. F. Miao (JHU and Nanjing University), Y. M. Lu and J. W. Cai (Institute of Physics, Chinese Academy of Sciences), has been supported in part by NSF DMR1262253.

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