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Distinguishing spin Hall MR from anisotropic MR by temperature dependence

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In bilayers consisting of a strong spin-orbit coupling metal such as Pt or Pd and a magnetic insulator such as yttrium iron garnet, magnetoresistance is found in the magnetic field range where the magnetization of YIG reverses. This magnetoresistance resembles the conventional anisotropic magnetoresistance (AMR) in ferromagnetic conductors, which arises from the difference in resistance between the current parallel and perpendicular to the magnetization. At room temperature, however, no difference is observed when the magnetization is rotated between these two orientations; therefore, this phenomenon is clearly not the conventional AMR. An alternative explanation is based on the magnetization-dependent spin current reflection effect, called the spin Hall magnetoresistance (SMR). In our bilayer systems, we find that a finite AMR appears and increases monotonically as the temperature is decreased. In the meantime, SMR increases first, reaches a peak at an intermediate temperature, and then decreases at low temperatures. We will show that this characteristic temperature dependence is consistent with the SMR model. The SMR peak occurs when the spin diffusion length is approximately equal to the metallic layer thickness. These two magnetoresistance effects coexist but can be distinguished from each other from their distinct temperature dependences.