First-principles study for spin Hall magnetoresistance in Co/Pt bilayer film system

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Understanding the transport phenomena in magnetic materials has been a crucial ingredient for designing novel materials with desired properties for spintronic applications. In bilayer systems of magnetic material (MM) and heavy metal (HM), the electrical resistance of the heavy metal layer can be tuned by varying the angle between the applied current and the magnetization direction of the magnetic material layer [1]. This effect is commonly known as the spin Hall magnetoresistance effect [2]. This attractive magnetic proximity effect (MPE) has been widely investigated experimentally. On the contrary, there are only few reports on the theoretical side. In the present work, we use the theoretical approach to study the SMR by using the first-principles calculation, full-potential linearized augmented plane wave method (FLAPW) [3] in order to design materials with high efficiency of SMR. We employed Pt|Co bilayer film system as our calculation model. In reference to previous work [4], the single layer Co is stacked on top of Pt substrates at the fcc site. Calculation of electric conductivity and spin Hall conductivity was based on linear response theory and Kubo formula [5]. We considered the electric conductivity and spin Hall conductivity while varying the magnetization directions in the system from x to z, where the z direction is perpendicular to the film plane. As a result, the resistance of the system increased by almost 2% when the magnetization direction is perpendicular to the plane compared to the in-plane magnetization case. We will present more detailed discussions on the obtained SMR properties and driving mechanisms of the SMR in the system.

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