Giant Orbital Magnetoresistance in Orbital Angular Momentum Dominated Magnets

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Generation and transport of orbital angular momentum (OAM) of conduction electrons in solids have gained theoretical and experimental interest in recent years with the advent of a new research field called orbitronics [1,2]. Unlike spintronics, where the generation of spin angular momentum from charge currents relies on the relatively weak spin-orbit coupling (SOC) mechanism (such as in Pt), orbital angular momentum can be directly generated from charge currents because the crystal momentum of charge carriers can directly couple to the orbital angular momentum. This results in a more robust, orders-of-magnitude larger generation of current-induced OAM; even in light, abundant, inexpensive and environmentally friendly materials (Cu, Al, Ti). These advantages position the new emerging field of orbitronics as a promising platform for future energy-efficient information processing and storage technologies. Despite the generation of orders of magnitude larger dynamic OAM, the fundamental obstacle to fully harness the power of this dynamic OAM for device applications is their low interaction efficiency with magnetization that in conventional transition metals is carried by spin angular momentum [3]. While spin currents interact efficiently with spin-based magnetization via a strong *s-d* exchange interaction, the dynamic OAM cannot couple in conventional magnetic materials with quenched OAM by any strong exchange interaction. Recently, a new class of magnetic materials with magnetic moments based on orbital angular momentum was identified, such as samarium nitride (SmN) and Neodymium nitride (NdN) [4,5]. In these materials the orbital moments provide a direct pathway for interaction between dynamic OAM and static orbital moment dominated magnetization. This eliminates the need for spin conversion and allows one to harness the full potential of orbitronics. By integrating such materials into all orbitronic devices, one can use the intrinsic advantages of orbital currents for ultrafast and low-energy magnetization control. This work highlights the potential of orbital-dominated magnetic materials as a foundation for next-generation orbitronic applications, paving the way for more efficient and scalable magnetoelectronic technologies.

References

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