Spin-orbitronic phenomena in nanostructures comprising transition metals, oxides and 2D materials

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Spin-orbit coupling based phenomena at interfaces comprising ferromagnetic (FM) metal, oxide (O) and nonmagnetic metal (NM) have been of great interest for spintronics including spin-orbitronics [1]. A major attention of scientific community has been also devoted to developments of emerging field of 2D and graphene spintronics [2]. Here we provide theoretical insights into perpendicular magnetic anisotropy (PMA) [1,3-9], Dzyaloshinskii-Moriya interaction (DMI) [9-13] at interfaces comprising transition metals, insulators and graphene. First, mechanisms of PMA [1,3-6] and of its variation under applied electric field (VCMA) [7] or via ionic migration [8] at FM/O interfaces are unveiled using first-principles approaches. Strong enhancement of the surface anisotropy of Co films at Co/graphene interfaces is also discussed [9]. Next, microscopic mechanisms of DMI behavior at FM/NM [10], FM/O [11,12] and FM/graphene [13] interfaces are elucidated. Several approaches for DMI enhancement using trilayers with different FM/NM or FM/O interfaces [11] important for observation of room temperature skyrmions [12] are proposed. Possibilities of controlling DMI by electric field (VCDMI) at NM/FM/O [11] or by hydrogenation at FM/graphene interfaces [14] are presented as well. Finally, DMI mechanisms and possibility of inducing skyrmions in 2D magnetic materials are introduced [15,16].

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