Spin Interactions in 2D Quantum Materials and Heterostructures

Saroj Prasad Dash
Professor, Quantum Device Physics Laboratory,
Microtechnology and Nanoscience, Chalmers University of Technology, Gothenburg, Sweden
Email: saroj.dash@chalmers.se

Two-dimensional (2D) quantum materials and their van der Waals heterostructures represent a novel platform to realize novel spin-based phenomena and device applications. Followed by the successful use of graphene, a vast plethora of 2D materials with complementary properties have been discovered, such as 2D insulators, semiconductors, magnets, and topological materials. Large-area CVD graphene could be used as a robust spin interconnect (1), spin multiplexing, and finally, the demonstration of multifunctional and reconfigurable spin logic gate operation by all-electrical means (2). In order to control the spin polarization in graphene, we engineered 2D material heterostructures by combining the best of different materials in one ultimate unit and realized strong proximity induced spin-orbit coupling (3) and magnetism (4). The graphene-based heterostructures are also useful for the detection of current-induced spin-polarization in topological materials (5) and proximity interaction in graphene-based heterostructures (6,7). Finally, room temperature spin-valve devices could be realized using van der Waals itinerant ferromagnet in heterostructures with graphene (8). These findings open a new platform for electrical creation and gate-control of spin polarization and provide new opportunities for all-2D heterostructure spintronic devices and integrated spin circuits.

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