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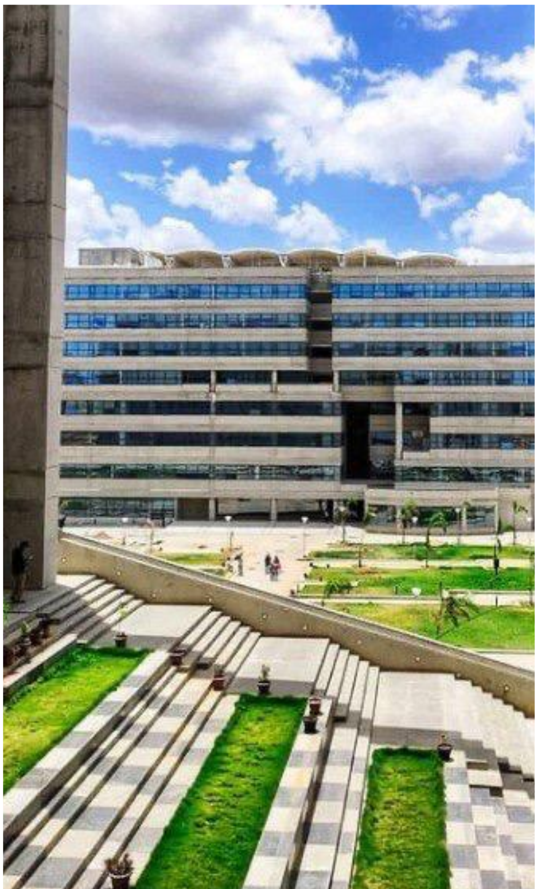
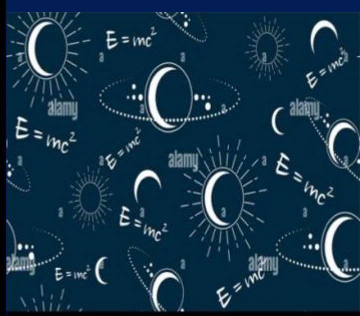
Engineering Science

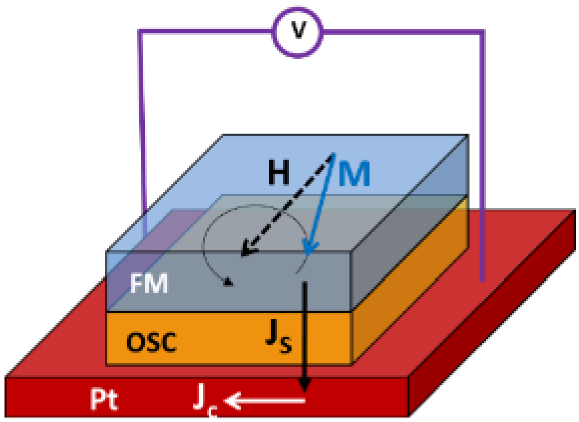



PhD Brochure

4. Organic spintronics: spin injection and transport at molecular spinterface

Dr. Venkata Rao Kotagiri and Dr. Chandrasekhar Murapaka

Spin orbit coupling (SOC) – a well-known but less explored until recently, has opened up new paradigm for controlling spintronic devices and a new frontier has been established as spin-orbitronics. In a SOC based device, the interface plays a crucial role. Typically, a ferromagnet (FM)/non-magnetic (NM) bilayer structure is used to explore novel properties like spin pumping (SP) and inverse spin Hall effect (ISHE) which are associated with the SOC. The choice of the NM layer is typically a heavy metal (inorganic) with large SOC strength. However, some of the major drawbacks of such FM/NM (inorganic) devices include small spin diffusion length (few nm) and short spin relaxation time (ns) which hinder practical realizations of these structures in a pure spin current spintronic device.
A totally new avenue of interface spintronics is FM/NM heterostructures where the NM layer is made from organic semiconductors (OSCs). It is believed that this novel interface manifests spin-dependent density of states due to interactions and hybridizations of organic molecules with the FM layer [M. Cinchetti et al., *Nature Mater* 16, 507–515 (2017)]. Such FM/OSC interface is termed as 'spinterface'. Moreover, relatively low SOC of OSCs offers a pathway to improve spin diffusion length and spin relaxation time by several orders. Importantly, organic spinterface is gaining momentum due to the observations of long spin diffusion length (hundreds of nanometers) and spin relaxation time (hundreds of microseconds) [Wang et al. *Nat. Electron.* 2, 98–107, (2019)]. Furthermore, the possibility of low-cost large-scale production and tunable chemical functionality of organic layer are added advantages for FM/organic heterostructures. Such functionalities are inaccessible in conventional FM/NM (inorganic) devices. Recently, spin mixing conductance ($g_{\downarrow\uparrow}$) – a parameter which determines the efficiency of spin current generation is found to have significantly large values. In this proposal, we would like to harness pure spin current in novel FM/organic interface by using an emerging class of two dimensional (2D) conjugated polymers which possess high charge carrier mobility and crystalline order. We aim to engineer molecular structures and their compositions at the interface in order to optimize the performance for pure spin current generation. The primary experiments include precise measurements of SP and ISHE in such heterostructures.



Related publications from our group:

1. R Gupta et al., "*Chemical Approach Towards Broadband Spintronics on Nanoscale Pyrene Films*", Angewandte Chemie, e202307458 (2023).
2. Talluri Manoj, et al., "*Giant Spin Pumping at Ferromagnet (Permalloy) - Organic Semiconductor (Perylene diimide) Interface*", RSC Advances 11, 35567 (2021).