Centre de Nanosciences & de Nanotechnologies

Introducing 2D Materials in Magnetic Tunnel Junctions

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The discovery of graphene has opened novel exciting opportunities in terms of functionalities and performances for spintronics devices. To date, it is mainly graphene properties for efficient in-plane spin transport which have been put forward.[1] We will present here experimental results concerning integration of graphene in vertical Magnetic Tunnel Junctions (MTJ), with strong technological potential.[2] We will show that a thin graphene passivation layer, directly integrated by low temperature catalyzed chemical vapor deposition (CVD),[3] allows to preserve a highly surface sensitive spin current polarizer/analyzer behavior. Characterizations of complete spin valves making use of graphene grown by CVD will be presented. The graphene layer prevents the oxidation of the ferromagnet, unlocking in turn the exploration of spin filtering phenomena at graphene/ferromagnet interfaces. We will discuss the measured experimental spin signals in light of bulk band structure spin filtering effect as usually observed with MgO, but also highlight the role of interfacial hybridization (a.k.a. spinterface) for spin selection with ab-initio calculations in support.[4] We will further discuss these observed spin filtering effects by analyzing results with other 2D materials (such as h-BN and WS2) integrated in MTJ devices. [5] Finally, we will expand the discussion to a novel pulsed laser deposition (PLD) approach for the definition of complex van der Waals heterostructures of 2D materials in MTJs. [6] This PLD growth approach unlocks the association in heterostructure of wide families of multifunctional 2D materials, including the most delicate ones. The different presented experiments unveil promising approaches for the quantum engineering of multifunctional 2D materials heterostructures for spintronics.

[1] Martin et al. Advanced Quantum Technologies 5, 2100166 (2022)
[2] Yang et al. Nature 606, 663 (2022)
[3] Weatherup et al. ACS Nano 6, 9996 (2012); Naganuma et al. APL 116, 173101 (2020)
[4] Piquemal-Banci et al., Nat. Comm. 11, 5670 (2020) ; Zatko et al. ACS Nano 16, 14007 (2022)
[5] Piquemal-Banci et al. ACS Nano 12, 4712 (2018) ; Zatko et al. ACS Nano 13, 14468 (2019)
[6] Godel et al. ACS Appl Nano Materials 3, 7908 (2020) ; Zatko et al. ACS Nano 15, 7279 (2021)

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