TMD Engineering of 2D-Magnetic Tunnel Junctions – From Barriers to Electrodes

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Spin-based electronics has already revolutionized data storage and readout technologies. Nowadays it targets a variety of new architectures like embedded MRAMs, spin logics or neuromorphic computing, which makes it one of the most promising post-CMOS approaches. Meanwhile, 2D materials and their combination in heterostructures have opened novel exciting opportunities in terms of functionalities and performances for spintronics devices. The broad family of 2D materials offers many possibilities to engineer the properties of layered stacks and devices in particular via interfacial exchange and proximity effects. One very attractive topic is the field of MTJs based on 2D materials (2D-MTJs).[1] Being able to control the physical behaviour of the MTJ is of crucial interest, in order to improve their functionality and efficiency. From major influence herby are electrodes and the tunnel barrier, in terms of interfaces and band alignments. Recent work utilised 2D materials to enhance barriers and their performance. Graphene has proved its strong potential as a barrier for MTJs with evidence for spin-filtering through band structure or strong hybridization effects (i.e. spinterface) achieving a record spin polarization of up to -98%. In parallel, advances within the broad Transition Metal Dichalcogenides family of 2D semiconductors and 2D ferromagnets have opened new possibilities to tailor spintronics properties further. As an example, we will show how TMDs could be integrated into a hybrid spin-valves 2D-MTJs and show layer-dependent spin filtering effects. We can show that the spin polarisation can be reversed depending on the number of layers. The layer thickness largely influences the band structure and thus allows control over the open spin channels for vertical electron transport. We will also discuss how to reach one step further with the large scale integration of these materials into tailored 2D heterostructures. For this we developed 2D ferromagnets based on $Fe_{3+x}GeTe_2$ which can act as a spin source. We will show that they can be grown in large scale using Pulsed laser deposition (PLD) and reach curie Temperatures (T_c) above room temperature (RT) while being integrated with other TMDs. We will highlight how these PLD grown ferromagnetic 2D layers could further reinforce the 2D materials family's potential for 2D-MTJs and how they open the way for the design of in-situ full 2D MTJ fabricated devices with artificial properties. [2,3]

References

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