Quantum Engineering of Spin-Filtering in WS_2-based Magnetic Tunnel Junctions Towards Large-Scale integration

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Introducing 2D materials in spintronics structures is foreseen to increase control over spin properties and extracted spin signals.[1] Graphene and h-BN have been the first 2D materials to show spin filtering properties in Magnetic Tunnel Junctions (MTJs). Recently, advances within the Transition Metal Dichalcogenides (TMDs) family of 2D semiconductors opened new possibilities to further tailor spintronics properties.
We will start by presenting a detailed process to integrate chemical vapor deposited WS_2, with step-by-step characterizations (photoluminescence, Raman spectroscopy,…) to ensure the high quality of the interfaces. The TMD is integrated in a hybrid spin-valve $Co/Al_2O_3/WS_2/Co$. The Co/Al_2O_3 is used here as a spin analyzer in order to probe the spin-polarized current from the 2D/Co interface.
We further validate the protocol by measuring magnetoresistance signals above the state of the art concerning MTJs based on 2D semi-conductors. Our main result is the study of a highly thickness dependent spin polarization of the WS_2/Co interface. We show that depending on the number of WS_2 layers stacked in contact with the cobalt electrode, we can tune the sign and amplitude of the extracted spin polarization. This unique behavior is further discussed with ab-initio calculations in support highlighting the band structure dependence of WS_2 and its influence on the spin transport in such MTJs[2].
Leveraging on this results, we will show how a large-scale pulsed laser deposition process of 2D semiconductors[3] carried at CMOS compatible temperatures, allows to engineer the band-gap landscape in these junctions, toward a fine control of 2D semiconductor based MTJ spin transport properties.[4]
We will finally discuss how our work unveils the potential of WS_2 for tunable band-gap spin filtering and compatibility to large-scale devices. As this band structure evolution is common to many other TMDs, our work also opens the way to the integration of many other members of this very large 2D materials family, in order to reveal their spin transport properties in MTJs.

References

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