

Growth of Self-Assembled Monolayers directly on a ferromagnetic metal surface

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Molecular spintronics, the combination of chemistry potential to the spin degree of freedom provided by spintronics, is considered to be more than an alternative to conventional spintronics with inorganic materials. Unconventional properties and strong potentialities offered by the flexibility, chemical engineering and low production costs of molecules, add to the opportunity that spin lifetime could be enhanced by several orders of magnitude compared with inorganic materials. Very recently it has been highlighted that the metal/molecule hybridization could strongly influence interfacial spin properties going from spin polarization enhancement to its sign control in spintronics devices [1].

In this scenario, while scarcely studied [2] [3], self-assembled monolayers (SAMs) seem to be the perfect toy barriers to further test these tailoring properties in molecular magnetic tunnel junctions (MTJs) since they are composed by a head, a body and an anchoring group that can be independently tuned thus allowing an easy engineering of the barrier.

We present nanodevices based on alkyl phosphonic acids SAMs used as tunnel barrier grafted on the half-metallic manganite (La,Sr)MnO₃ (LSMO) [4]. The prepared LSMO/SAMs/Co magnetic tunnel junctions present an area of only few 10 nm² to allow the study of the local properties of the system and to avoid defects inside the barrier.

We will present the atypical bias voltage dependence of tunnel magnetoresistance (TMR) highlighting the peculiar role of molecules in the spin dependent tunnelling transport (Figure 1a) [5].

We will also show the influence of the molecule chain length on the tunnel resistance and the TMR (Figure 1b) [5]. These results confirm the high quality of the devices and unravel the potential of self-assembled monolayers as tunnel barrier for conventional spintronics applications and beyond, such as spinOLEDs which relies on spin injection at high bias voltage.

However, as LSMO's surface Curie temperature (T_c) is close to room temperature, spintronics effects in LSMO-based devices are expected only at low temperature. So, in order to obtain spintronics effects at room temperature it will be desirable to substitute LSMO by a ferromagnet of higher T_c , as for example ferromagnetic (FM) metals like cobalt (Co). Unlike LSMO, FM metals readily oxidize and is not surprisingly that SAM grafting protocols over FM electrodes are almost non-existing. The formation of SAMs on bare magnetic metals is a challenging task since surface oxidation (which suppresses surface ferromagnetic properties) during SAMs grafting has to be avoid. In this communication, we present our first results towards the integration of SAMs into room temperature spintronics devices. We have developed the grafting protocols necessary for the integration of SAMs on 3d FM metals with solution approaches. We will present the formation of SAMs on Co under ambient conditions and in inert atmosphere without oxidation of the Co substrate (Figure 2). By standard characterizations it will be probe that only thiol group can be successfully grafted on ferromagnetic surfaces whereas phosphonic acids group works with oxidized metal surfaces.

References

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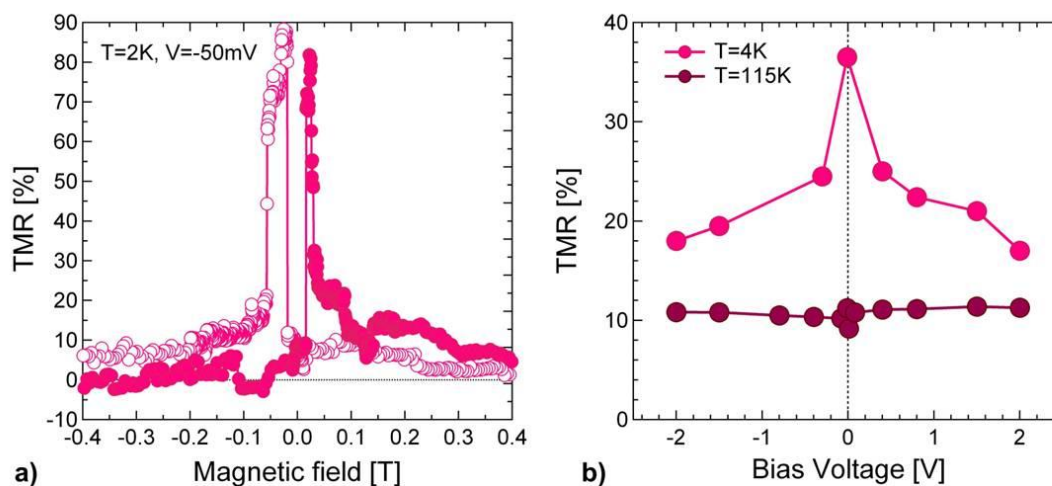


Figure 1. a) R(H) characterization of a LSMO/SAM/Co nanojunction at T=2K. b) TMR characterization of a LSMO/SAM/Co nanojunction depending on bias voltage and temperature.

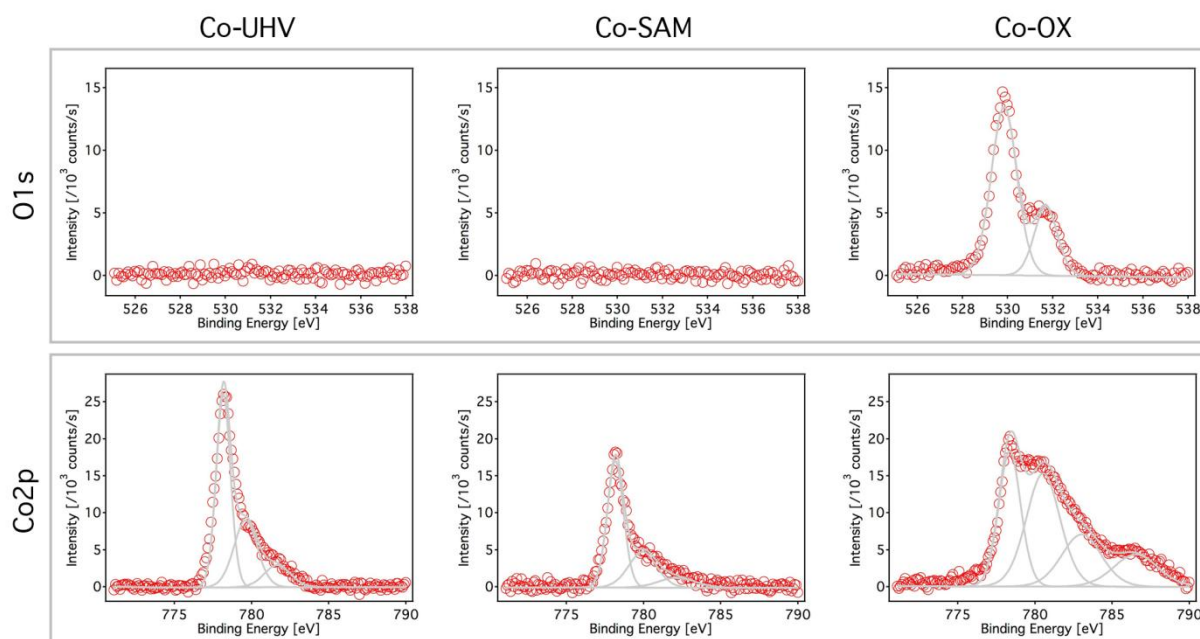


Figure 2. Co2p and O1s high resolution XPS spectra of a Co-SAM sample measured after 20 s of ion milling. In this sample, cobalt was sputtered, the sample was transferred to a glove box, SAM was grafted and the sample transferred again to the sputtering chamber without breaking the inert atmosphere and capped with 10 nm of gold. XPS spectra of oxidized (Co-OX) and unoxidized (Co-UHV) cobalt have been added for comparison.