The role of interface effects on the magnetic response of MgO/Co/MgO trilayers

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Magnetic tunnel junctions (MTJ) based on MgO tunnel barrier exhibit the highest known tunnel magnetoresistance (TMR) which can be employed in the development of sensors and data storage devices of extraordinary sensitivity. However, as experimentally realized TMR values are still an order of magnitude smaller than the theoretical predictions, a considerable effort has been devoted to the understanding of detrimental factors for TMR, and to the search for remediations.

Processes occurring at the interface between the MgO and the magnetic electrodes are known to heavily affect the TMR and the magnetic anisotropy of the electrode. Recently, this region has attracted even more interest due to the unsolved controversy regarding the existence of a magnetic dead layer at the interface between MgO and the magnetic electrode [1, 2, 3]. At the MgO/Co interface, no evidences of the dead layer were found [4, 5]. However, recent investigations on MgO/Co/MgO trilayers show Co-O orbital hybridization and CoO formation might occur depending on the thickness of the Co and MgO layers, on the interfaces roughness, and on annealing treatments [6]. These structural modifications were found together with drastic changes in coercivity and easy axis direction, thus confirming the primary role played by the interface effects on the overall magnetic response.

In this work, we explore the buried interfaces of MgO/Co/MgO systems as a function of the Co thickness and annealing temperature. Our investigation is based on the complementary information yielded by Magneto-Optic Kerr Effect (MOKE), X-ray Magnetic Circular Dichroism (XMCD) and Soft X-ray Resonant Magnetic Reflectivity (SXRMR). Exploiting the elemental and depth sensitivity provided by SXRMR, the chemical, structural and magnetic properties of the buried interfacial regions between MgO and Co were studied. Furthermore, the local magnetic moments and the direction of the easy magnetization axis were investigated as a function of depth, by XMCD. The thorough description we present includes thickness and roughness of each interface, oxidation states of Co, charge transfer effects at the MgO/Co interfaces, and Co oxidation/reduction processes. Furthermore, we address the thickness-and thermal- dependencies of the observed interface phenomena while accounting for the presence of a magnetic dead-layer and for the effects related to Oxygen migration/diffusion.
This complex description provides fundamental details for the understanding of how the interfacial processes affect TMR in MTJs.

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