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Control of Magnetic Properties Across Metal to Insulator Transitions[1]

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Controlling the magnetic properties of ferromagnetic (FM) thin films without magnetic fields is an on-going challenge in condensed matter physics with multiple technological implications. External stimuli and proximity effects are the most used methods to control the magnetic properties. An interesting possibility arises when ferromagnets are in proximity to materials that undergo a metal-insulator (MIT) and structural phase transition (SPT). The stress associated with the structural changes produces a magnetoelastic anisotropy in proximity coupled ferromagnetic films that allows controlling the magnetic properties without magnetic fields. Canonical examples of materials that undergo MIT and SPT are the vanadium oxides (VO_2 and V_2O_3). VO_2 undergoes a metal/rutile to an insulator/monoclinic phase transition at 340 K. In V_2O_3 the transition at 160 K is from a metallic/rhombohedral to an insulating/ monoclinic phase. We have investigated the magnetic properties of different combinations of ferromagnetic (Ni, Co and Fe) and vanadium oxide thin films. The (0.32%) volume expansion in VO_2 or the (1.4%) volume decrease in V_2O_3 across the MIT produces an interfacial stress in the FM overlayer. We show that the coercivities and magnetizations of the ferromagnetic films grown on vanadium oxides are strongly affected by the phase transition. The changes in coercivity can be as large as 168% and occur in a very narrow temperature interval. These effects can be controlled by the thickness and deposition conditions of the different ferromagnetic films. For VO_2/Ni bilayers the large change in the coercivity occurring above room temperature opens the possibilities for technological applications.

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