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Study of spin valve structures with weak and strong interlayer coupling

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Abstract – The IrMn/Co/Ru/Py and IrMn/Py/Cu/Co (Py = $Ni_{81}Fe_{19}$) spin valves have been studied by magnetization measurements. The samples were grown by sputtering deposition on Si(111) substrates. In the first system, the Ru thickness was varied between 24 and 42 Å for studying the case of weak interlayer coupling and strong exchange anisotropy, while in the other system, the Cu thickness was varied between 6 and 20 Å to study the case of strong interlayer coupling and low exchange anisotropy. The shape of the hysteresis loops show to be sensitive to the thickness of the spacers, which controls the type and strength of the interlayer coupling.

Spin valves consists of the stacking of an antiferromagnetic (AF) layer and two ferromagnetic (FM) layers separated by a non-magnetic (NM) one, resulting in the AF/FM/NM/FM structure, where the FM layers can be the same or different magnetic materials. The main interactions considered for modeling the magnetic behavior of this system are exchange bias effect [1] at the AF/FM interface, the indirect magnetic coupling between the FM layers mediated by the NM spacer, which is described by the bilinear (J_1) and biquadratic (J_2) constants. Depending on the thickness of the NM layer, the indirect coupling favors a parallel ($J_1 > 0$) or antiparallel ($J_1 < 0$) alignment between the FM layers, moreover, the strength of this coupling decreases for increasing NM layer thickness. Furthermore, the uniaxial anisotropy of the FM layers, the Zeeman and demagnetizing energy are also considered. The interplay between the exchange anisotropy and the interlayer coupling modifies the magnetic properties of the spin valves. Theoretical calculations for the case of weak interlayer coupling show that the whole system can behaves as two uncoupled layers with magnetic properties different to that of the separated AF/FM and FM initial structures, while for the strong interlayer coupling case, the whole system behaves as a unique AF/FM system [2].

This work deals with the experimental study of the IrMn(150Å)/Co(50Å)/Ru(t_{Ru})/NiFe(50Å) spin valves, with weak interlayer coupling strength and of the IrMn(60Å)/NiFe(40Å)/Cu(t_{Cu})/Co(40 Å), having strong interlayer coupling strength, by static magnetic characterization. The magnetization *vs.* magnetic field measurements were performed with a vibrating sample magnetometer (VSM) from Quantum Desing. The phenomenological model for interpretation considers the exchange bias effect in the framework of the Mauri model and the bilinear and biquadratic coupling constants. Figures 1 and 2 show the hysteresis loops obtained at room temperature for the spin valves with t_{Ru} = 36 and 42 Å. The magnetic field was applied along the easy axis. The shifts to the positive and negative sides of the small loop, along the field axis, are attributed to the weak antiferromagnetic and ferromagnetic coupling between Co and Py, respectively.

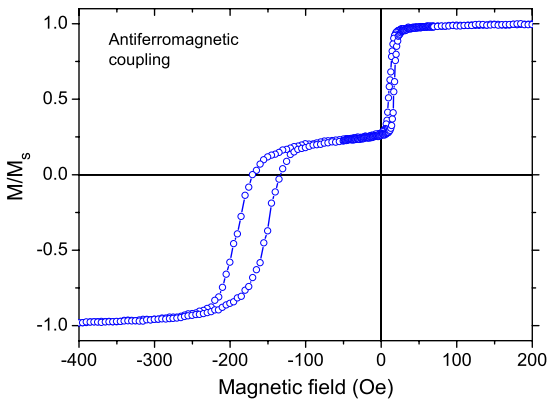

Figure 1: Hysteresis loop of the IrMn(150Å)/Co(50Å)/ Ru(36Å)/Py(50 Å)/Ru(50 Å) spin valve.

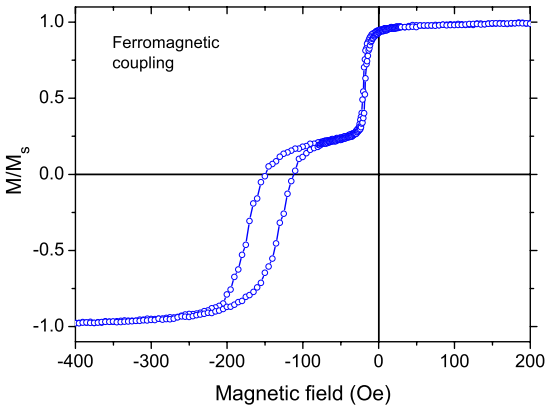

Figure 2: Hysteresis loop of the IrMn(150Å)/Co(50Å)/ Ru(42Å)/Py(50 Å)/Ru(50 Å) spin valve.

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