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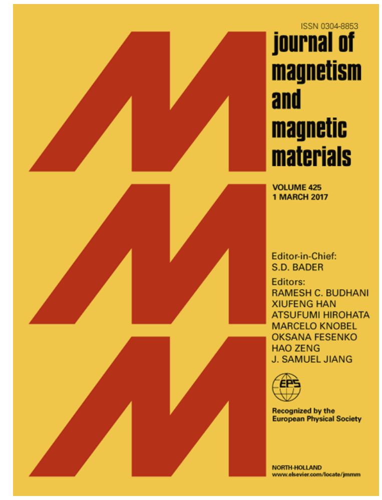

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Effect of the strong coupling on the exchange bias field in IrMn/Py/Ru/Co spin valves

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Abstract

The IrMn/Py/Ru/Co (Py = $Ni_{81}Fe_{19}$) spin valves have been produced by sputtering deposition and analyzed by magnetization measurements and a theoretical modelling of their exchange interactions, based on the macro-spin model. The Ru thickness was grown between 6 and 22 Å, which is small enough to promote strong indirect coupling between Py and Co. Results of measurements showed a large and gradual change in the shape of hysteresis loops when the Ru thickness was varied. The theoretical analysis, using numerical calculations based on the gradient conjugate method, provides the exchange coupling constants (bilinear and biquadratic), the exchange anisotropy fields and the magnetic anisotropy fields (uniaxial and rotatable). The exchange bias fields of spin valves were compared to that of a IrMn/Py bilayer. We found that the difference between these fields oscillates with Ru thickness in the same manner as the bilinear coupling constants.

Keywords: Spin valves, exchange coupling, magnetic anisotropy

The spin valves structures, proposed by Dieny et al. [1], received a lot of attention due to their potential use in sensors and storage devices [2]. In general, these systems consist on two ferromagnetic (FM) layers, FM_1 and FM_2, separated by a non-magnetic (NM) metal, one of them is in contact with an antiferromagnetic (AF) material, giving the AF/FM_2/NM/FM_1 multilayer, as seen in Fig. 1. In many works, the NM layer is large enough for weakly coupled [3, 4, 13] or uncoupled FM layers. The FM_1 layer has its magnetization free to rotate in response to the application of an external field, while, the FM_2 layer is the fixed layer and its magnetization is pinned by the exchange coupling with the AF material. Here, we present an analysis of the IrMn/Py/Ru/Co structure with the FM layers strongly exchange coupled, considering both theoretical and experimental point of views. The theoretical study is based on the macro-spin model, using the phenomenological Helmholtz free energy. This model takes into account the Zeeman energy, the demagnetizing energy, uniaxial anisotropies for

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