Study of magnetization dynamics in Fe/FeSi/Fe-trilayes using Nuclear Resonant Scattering of Synchrotron Radiation

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We have studied the interlayer coupling between two thin Fe-films, separated by an iron-rich spacer layer ($Fe_{0.57}Si_{0.43}$), and grown on a Au-buffered MgO substrate. Magnetization measurements on the sample reveal a temperature dependent biquadratic coupling, which reaches a maximum coupling strength near 200 K and vanishes completely near room temperature [1]. Due to the remarkable resemblance with the interlayer coupling in Fe/Cr multilayers [2], we anticipate that this anomalous behavior can be explained by the presence of magnetic moments in the FeSi spacer, which start to fluctuate and to mediate the biquadratic coupling above a critical temperature. To verify whether fluctuating magnetic moments are indeed present in the spacer, the magnetic state of the FeSi was studied by using Nuclear Resonant Scattering of synchrotron radiation (NRS). As NRS is an isotope selective technique, information about the dynamics in the spacer could be obtained by selectively enriching the silicide spacer with the ^{57}Fe isotope, while growing the metallic Fe layers with ^{56}Fe.

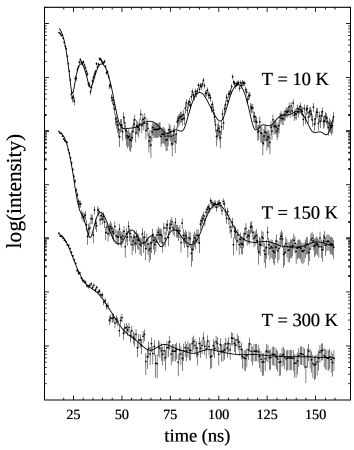

Figure 1: Evolution of the measured timespectra as a function of increasing temperature.

Time spectra were recorded in a temperature range from 10 K up to room temperature. The shape of the time spectrum undergoes a drastic evolution with changing temperature (figure 1). At low temperatures, a pronounced quantum beat pattern can be observed. As temperature increases, the quantum beats in the spectrum gradually disappear, evolving to an exponential decay at room temperature.

The different spectra were analyzed by means of the fitting program CONUSS [3]. The FeSi spacer showed four different hyperfine fields, which are frozen in at low temperatures. At higher temperatures, timespectra could be analyzed by allowing these hyperfine fields to fluctuate between different directions, and accurate values of the fluctuation frequencies for each hyperfine field could be obtained. The higher the temperature, the higher the deduced fluctuation frequency. At room temperature, values in the MHz regime were obtained. Thus, our measurements clearly reveal the relation between the microscopic properties of the spacer and the temperature dependence of the interlayer coupling.

[1] B. Croonenborghs, *Magnetostatic coupling mediated by metastable FeSi*, Ph.D. thesis, Katholieke Universiteit Leuven, 2004.
[2]J. Meersschaut et al., Phys. Rev. Lett. 87 (2001)107201.
[3] W. Sturhahn, Hyp. Interact. 125 (2000) 149.