Magnetism of ultrathin iron films seen by the nuclear resonant scattering of synchrotron radiation

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Conversion electron Mössbauer spectroscopy proved in the past to be very useful in studying surface and ultrathin film magnetism with monolayer resolution [1]. Twenty years later, its time-domain analogue, the nuclear resonant scattering (NRS) of synchrotron radiation showed up to be by orders of magnitude faster and more efficient. Recent developments at the beamline ID18 at ESRF Grenoble made possible investigations *in situ*, under ultrahigh vacuum (UHV). The combination of UHV conditions and the high brilliance of the third generation synchrotron source provided us unique possibility to probe the evolution of spin structure in epitaxial Fe films on a tungsten W(110) *via* the accumulation of the high quality time spectra, directly during the ^{57}Fe film growth. Two different thickness regimes where the most intriguing properties in the past have been found were investigated: i) ultrathin films with the thickness in the range 0.5 - 4 ML when the onset of ferromagnetic behavior is expected [2], and (ii) Fe films with thickness of few tens of ML, in the vicinity of the in plane spin reorientation transition (SRT) [3]. A complex morphology of the ultrathin Fe films results in a non-collinear magnetic structure derived from the numerical analysis of the grazing incidence NRS data. This structure is related to the film morphology characterized by a deviation from a layer-by-layer growth mode and periodic misfit dislocations that develop beyond the first monolayer. Competition of out-of-plane and in-plane magnetic anisotropy for double layer Fe patches and for thicker Fe areas, respectively, leads to a complex spin structure at the buried layers, which could not be solved using traditional methods. A layer resolved map of the hyperfine magnetic fields could be obtained for the first time. Even more spectacular results were obtained for the dynamics of the in-plane SRT. Based on the NRS analysis, a new model of the transition has been proposed. The thickness induced transition of the magnetization from [1-10] to [001] direction originates at the Fe/W(110) interface and occurs through transient fan-like magnetization structures.

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[1] J. Korecki, U. Gradmann, Phys. Rev. Lett. **55** (1985) 2491;
M. Przybylski, U. Gradmann, Phys. Rev. Lett. **59** (1987) 11522
[2] J. Elmers, J. Hauschild, U. Gradmann, Phys. Rev. B **59** (1999) 3688;
O. Pietzsch, A. Kubetzka, M. Bode, R. Wiesendanger, Phys. Rev. Lett. **84** (2000) 5212
[3] U. Gradmann, J. Korecki, G. Waller, Appl. Phys. A **39** (1986) 101

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