MAGNETIC PHASE AND DOMAIN EVOLUTION OF ANTIFERROMAGNETICALLY COUPLED MULTILAYERS

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Nanotechnology is one of the research priorities of present-day industrial societies. The vast amount of emerging applications of possible miniaturization was predicted by Richard Feynmann already in 1959 in his famous lecture, “There's Plenty of Room at the Bottom”. In our days, the potential benefits of nanotechnology in information technology, advanced manufacturing, medicine and health, transportation, environment and energy industry, etc. are enormous.

Giant Magnetoresistance (GMR) is also based on nanotechnology, in particular on thin magnetic films. GMR has made its way to applications like magnetic sensors, spin valves, spin-tunneling junctions and the magnetic random access memory (MRAM). The underlying effect, viz. the antiferromagnetic (AF) coupling of magnetic layers was discovered in 1986 by Grünberg *et al.* on a trilayer of ferromagnetic Fe layers sandwiched by Cr spacers. Despite the fact that AF coupling was found in many multilayer (ML) systems, Fe/Cr MLs certainly belong to the most investigated ones. This is partly due to the still not fully understood coupling behavior of this system.

Another aspect of the AF-coupled MLs is their domain structure. In contrast to ferromagnetic films and structures in a strongly AF-coupled ML, the stray field of the domains is in large compensated thus other forces may influence the appearance of the domains. This is also obvious from the comparison of the patch-like AF domains to the characteristic ripple domains of ferromagnetic thin films. Formation of patch domains is mainly governed by fluctuations of the AF coupling resulting in a lateral distribution of the saturation field. The seemingly small effect of external field believed to prohibit the manipulation of the AF domains. However, one may wish to control the domain size, a parameter profoundly influencing the noise of magnetoresistive devices.

The phase diagram of AF-coupled MLs with different phenomenological (mainly biquadratic) coupling terms and magnetic anisotropies still holds new phenomena in store to describe. For example, in a very recent article J. Meersschaut *et al.* reported on experimental evidences of the hard-axis spin-reorientation transition, a phenomenon also discussed in the thesis. This transition may exist in AF-coupled Fe/Cr MLs with fourfold in-plane anisotropy.

Not too many papers have been published so far on the morphology of AF domains, due to the difficulties in direct visualization of these compensated objects. Therefore indirect methods, first of all those based on photon and neutron scattering, play an indispensable role in studying domains in AF-coupled multilayers. Scattering techniques often deliver valuable information about AF domains. For example, the first experimental evidence of the rapid growth of the AF domains during the bulk spin flop transition was discovered by our group using Synchrotron Mössbauer Reflectometry (SMR) and Polarized Neutron Reflectometry (PNR).

In the first part of the thesis an introduction is given to the phenomenological models of AF-coupled MLs. The effects of finite stacking, anisotropies and different coupling terms are discussed. Phase diagrams are calculated for MLs with fourfold anisotropy. After the theoretical introduction, the Fe/Cr ML is presented. The structure and the magnetization of the sample are fitted with various experimental techniques. An extended bilinear-biquadratic (BB) model was developed to fit the magnetization loops. The main aim of the work was to coherently describe the phase and domain transitions of the AF-coupled MLs. For this purpose a short introduction to the momentum space and the applied methods (SMR and PNR) is given. Two first-approximation theories for domain ripening are also presented. Direct evidence of the bulk spin flop transition is given and, in the final part of the thesis, the domain measurements are discussed.