Quantitative Contrast Evaluation in Magnetic Force Microscopy

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Magnetic force microscopy (MFM) is one of the most important tools in magnetic imaging due to the similarity of this method to the write/read process in magnetic storage devices and the comparatively low sample preparation requirements. However, a disadvantage is the fact that it provides very limited quantitative information since the exact magnetic configuration of the imaging tip is generally unknown. Several approaches have been undertaken in order to calibrate tips from the images of known structures such as microfabricated current patterns [1] or by calculating an image transfer function from an assumed magnetization distribution [2].

Not only the absolute measurement of magnetic stray fields is affected by this problem. Also the evaluation of shape and size of magnetic domains is greatly complicated by the extended stray field of the tip, which is geometrically convoluted with the domain structure during the imaging process. In general, a simple deconvolution is not possible because of the unknown transfer function of the tip. However, quantitative conclusions not dependent on specific transfer functions can still be drawn.

In this contribution, a method is presented which allows the size determination of isolated domains and single reorientation processes in a way that is not affected by this convolution . Taking into account the integrated contrast of each individual domain in frequency-modulated dynamic force microscopy images, it is possible to calculate the relative amount of contributing magnetic charges. For out-of-plane magnetized thin films, this quantity is proportional to the area of the underlying domain structure. A calibration of this method can be obtained by continuously acquiring images following a major hysteresis loop under high stability conditions [3]. We present the theoretical background of this evaluation method as well as its application to the magnetization reversal of ferromagnetic thin films with out-of-plane anisotropy [4].

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