THE CANTICLEVER: A DEDICATED PROBE FOR MAGNETIC FORCE MICROSCOPY

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With the current rate of increase in areal density of magnetic recording systems, todays resolution of MFM needs to be improved in order to remain useful as a measurement tool [1]. The resolution of MFM is amongst others determined by the geometry of the magnetic tip, which for commercial probes consists of a thin magnetic coating deposited on a pyramidal Si AFM tip. Analysis of the imaging process shows that the shape of these tips is not ideal. For higher resolution, the tip must be shaped as an elongated bar with a flat front end [2]. In this contribution we present a completely new MFM cantilever, the *CantiClever*, which is not derived from traditional AFM probes but optimized for MFM.

Our design incorporates the cantilever and the magnetic tip in a single manufacturing process with the use of silicon micromachining techniques, allowing for batch fabrication of the probes. We realise the ideal tip shape by deposition of magnetic material (Co) on the side of a free hanging silicon nitride layer, the *tip plane* (see figure 1). In contrast with conventional MFM cantilevers, our fabrication process enables precise control of all dimensions of the magnetic tip, resulting in a very thin magnetic element with high aspect ratio. The width and thickness of the magnetic tip are defined by the thickness of the silicon nitride layer and the magnetic layer respectively. The length of the tip, 20 μm, is defined by photolithography.

One of the first results, an MFM scan of 0.25 μm bits written in a perpendicular harddisk medium is shown in figure 1. For this measurement we used a DI3100 MFM with a 40 kHz cantilever which had a 100 nm tip plane coated with a 30 nm cobalt layer. Reduction of the SiN and Co layer thickness will result in an increase in resolution, the target resolution being 10 nm. In this paper further optimization of the probes and high resolution measurements will be shown, as well the possibility to use the tip plane concept for the integration of different types of sensors, such as MR elements, on cantilevers.

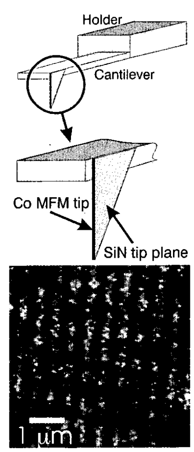

Figure 1: CantiClever design and MFM measurement

[1] L. Folks *et al.*, Applied Physics Letters **76**, 909 (2000)
[2] S. Porthun *et al.*, Applied Physics A **66**, S1185 (1998).

A SYNTHETIC MULTIPLE LAYER TIP FOR MAGNETIC FORCE MICROSCOPY

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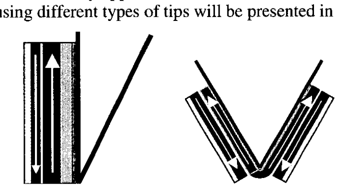
Magnetic force microscopy (MFM) is widely used to study the magnetic domain and magnetization switching processes of magnetic materials. Although under optimized conditions, it offers a spatial resolution of about 20nm, there always is a demand for even higher resolutions. The most popular approach for achieving a higher resolution is to sharpen the tip itself using focused ion beam trimming [1]. Although this technique has proven effective in improving the resolution, it is only up to a certain extent because the lateral size of the tip is not the only factor that determines the resolution of MFM; the distribution of magnetized coatings in the depth direction also affects the resolution substantially. To address the latter issue, tips with localized magnetic coatings have been proposed [2]. In addition to the resolution-related issues, the MFM is also known to have difficulties in imaging the domain structure of soft magnetic materials [3]. To reduce the tip-sample interaction imaging has to be performed either at a large lift-height or using a low moment tip, both of which will lead to a degradation of the image quality.

In this work we proposed a tip consisting of a synthetic multiple layer coating. It is hoped that this tip will partially solve both of the problems mentioned above for the MFM. Fig.1 (a) shows a schematic of the proposed tip. The magnetic coating consists of a seed / adhesion layer, an anti-ferromagnetic layer, two ferromagnetic (FM) layers separated by a thin Ru layer, and a protective layer. The total moment of the tip is approximately given by the difference of the moments of the two FM layers. To further localize the moment at the tip-top, the thickness of the two FM layers can be chosen to be the same and the top FM layer is selectively etched off to have a net moment at tip-top, as shown schematically in Fig.1 (b). To prove this concept, an experiment has been performed to image the domain structure of a 5x5μm permalloy element with a thickness of 20nm using a tip with a structure of Ta3/NiFe2/CoFe1.5/Ru0.8/CoFe8, where the unit of thickness is in nm. The result is shown in Fig.2. A four-domain closure structure has been obtained without any apparent domain wall curvature. The results on other different types of materials using different types of tips will be presented in the meeting.



(a) (b)

Fig.1. Schematic of synthetic tips with different types of structures. (a) different thickness for the two FM layers; (b) same thickness for the two FM layers, but the top layer is partially etched of using FIB.

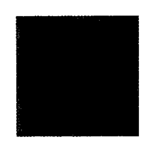


Fig.2. MFM image of a 5x5μm permalloy element.

[1] A. Kikukawa, S. Hosoka, Y. Honda, and S. Tanaka, Appl. Phys. Lett. 61, 2609 (1992).

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