NT-MDT
Molecular Devices and Tools for NanoTechnology
http://www.ntmdt.com

Application Notes

Magnetic measurements

MFM MEASUREMENTS WITH VARIABLE EXTERNAL MAGNETIC FIELD

The design of the **NT-MDT SPMs** allows applying of variable external magnetic field during measurements. The experiments with external magnetic field enable to observe the magnetization reversal processes and other effects that depend on magnetic fields. Fig.1 shows scheme of system that produces in-plane field up to 1500Oe in the gap between magnetically soft wires. Magnetic field is produced by electromagnet.

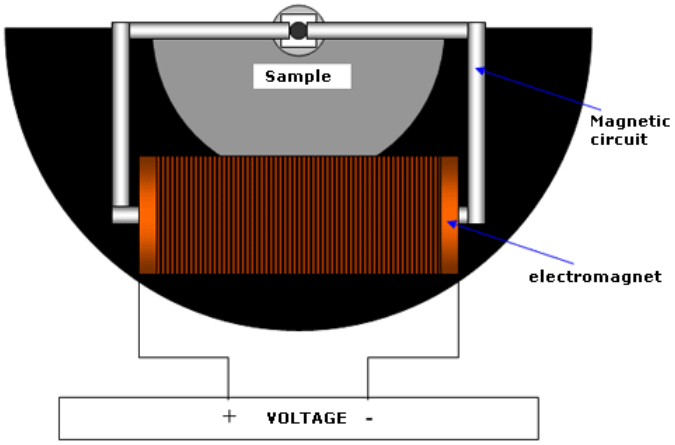
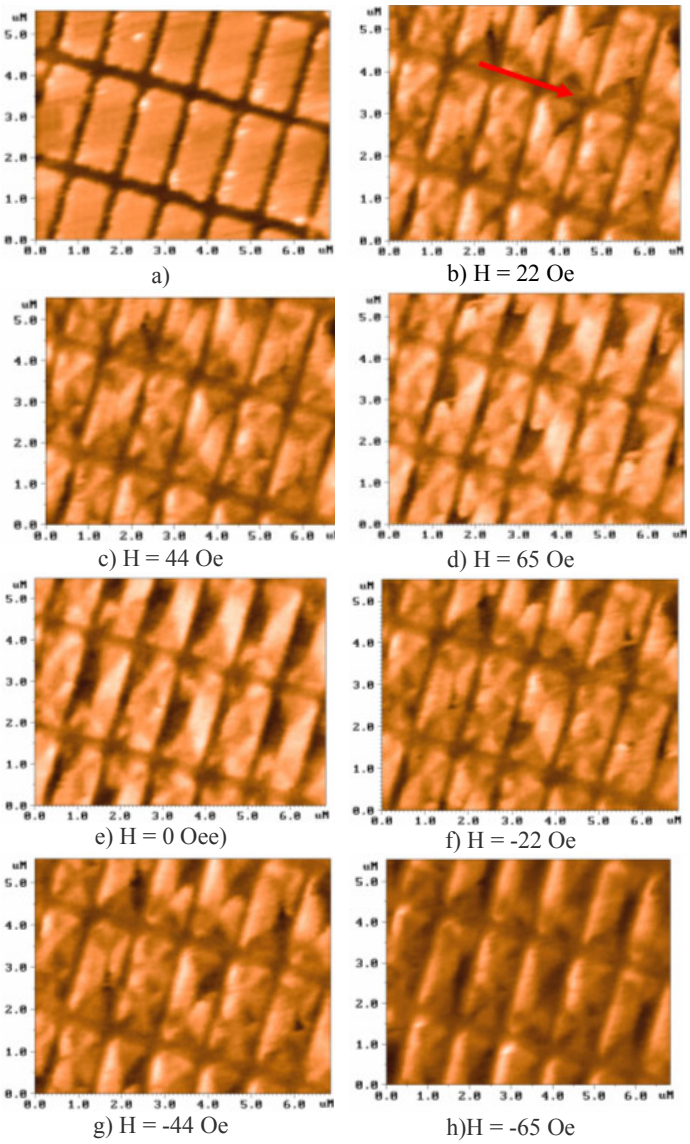


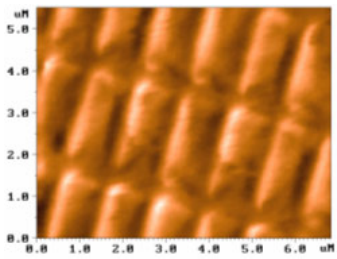
Fig. 1 Scheme of external field source

Examples of the using of the external magnetic field:

- Changes of the domain structure of permalloy rectangles

Fig. 2 demonstrates the domain structure of permalloy pattern at different value of external magnetic field. The silicon tip coated by permalloy film was used in this experiment. Magnetically soft tip helps to prevent magnetization reversal in the sample.



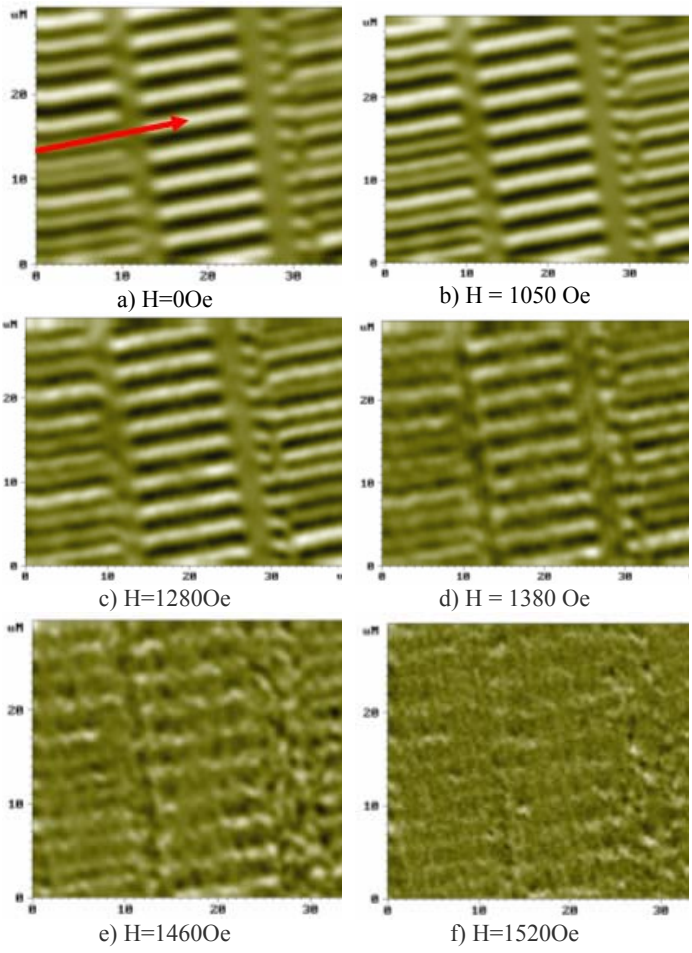


i) H = 0 Э

Fig. 2 a) Topography of the sample. b)- i) Series of MFM images for same area at various external magnetic field . External magnetic field is directed along short axis of rectangles b).

- Demagnetization of the hard disk

Fig. 3 shows series of MFM images of hard disk for the same area at different values of the external field. The external magnetic field increases from 0 up to 1520 Oe from a) to f). The magnetic field is directed along arrow. The disappearing of the magnetic contrast caused by demagnetizing of the sample is seen. Magnetic contrast is absent after switching off of external field, while magnetic properties of the tip remain the same.



a) H=0Oe b) H = 1050 Oe

c) H=1280Oe d) H = 1380 Oe

e) H=1460Oe f) H=1520Oe

Fig. 3 (a-f)

Series of MFM images of hard disk for the same area at different values of the external field. Silicon cantilever covered by 100nm SmCo was used for MFM measurements. In-plane external magnetic field was applied along arrow.

- In situ observation of the magnetization reversal of cobalt pattern

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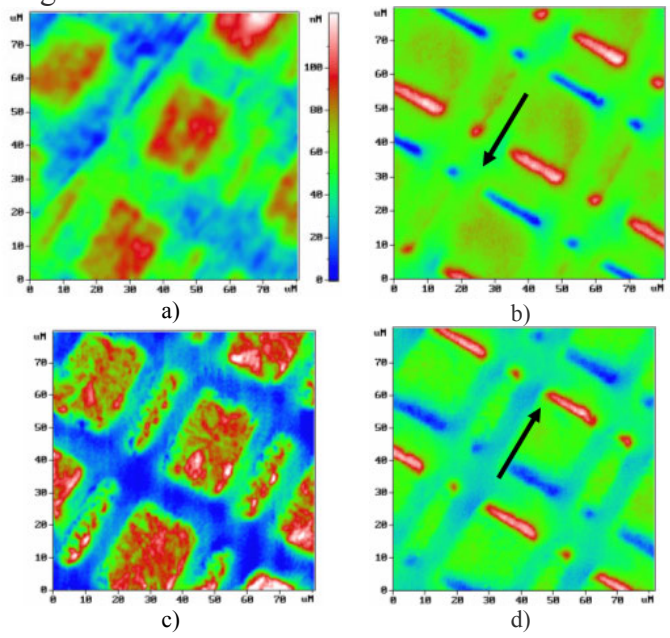
The studied sample was Co film (40nm thick) deposited on high-oriented pyrolytic graphite in the form of the micron size rectangles (Fig. 4a). Fig. 4b-d corresponds to AC MFM images, obtained by two-pass method. The values of the external field were 100Oe, 0Oe, and -100Oe for Fig.4 b, c, and d respectively. The direction of the external field marks by arrow. The opposite magnetization direction in the cobalt patterns is clear seen from Fig. 4b) and Fig. 4d): the poles trade places. All cobalt patterns are magnetized uniformly in these cases. Fig. 4c) demonstrates the domain structure in cobalt, which formed at zero external field. The domains with different shape are seen on Fig. 4c). In some cases the external field helps to separate the topography and the MFM image. This is important when topography strong correlates with magnetic structure.



a) b)

c) d)

Fig. 4

- Garnet film in external magnetic field

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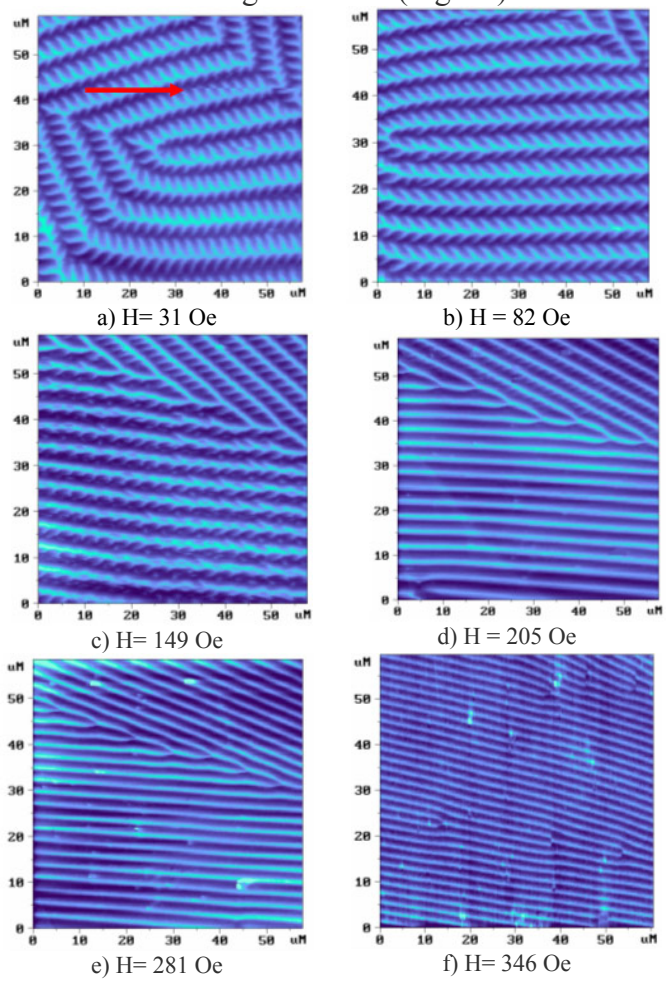
Previous examples have been made with SOLVER P47 (scanning by sample). SOLVER P47H (scanning by cantilever) has more convenient design for additional equipment under head. Fig. 5 shows the example of using external magnetic field with SMENA head. Domain structure of the inhomogeneous film of yttrium iron garnet with substantial variation of anisotropy field across the film thickness has been studied in various magnetic fields directed along red arrow (Fig. 5a).



a) H= 31 Oe b) H = 82 Oe

c) H= 149 Oe d) H = 205 Oe

e) H= 281 Oe f) H= 346 Oe

Fig. 5

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