Magnetic force microscope in an external controllable magnetic field

L.A. Fomin, K.M.Kalach, G.M. Mikhailov
Institute of Microelectronics technology, 142432 Moscow district, Chernogolovka;

V. A. Bykov, S.A. Saunin
NTMDT, Zelenograd.

The magnetic force microscope was designed as a device for measuring of a local magnetization in the vicinity of magnetic material surfaces with a high spatial resolution [1]. Most investigations with the help of this device were performed in the absence of an external magnetic field [2]. The devices with option of applying the external controllable magnetic field were only appeared during recent years. The difficulty in this device desiring is to create a magnetic field controllable in wide range of its intensities, where high power sources are needed. Their combination with a high-resolution scanning probe microscope (SPM) requires solving a lot of engineering challenges. Many applications, where magnetic materials are used requare to investigate a local magnetization of the samples in an external magnetic field. The intensity of this field would like to be varied continuously in the range of plus - minus several kilooersted with one oersted precision [3].

In this work the results of application and design of the magnetic force microscope developed on the base of SPM P-47 NTMDT are presented. This device allows measuring a local magnetization in the vicinity of the sample surfaces in the external controllable magnetic fields with its strength up to plus-minus 2500 Oe.

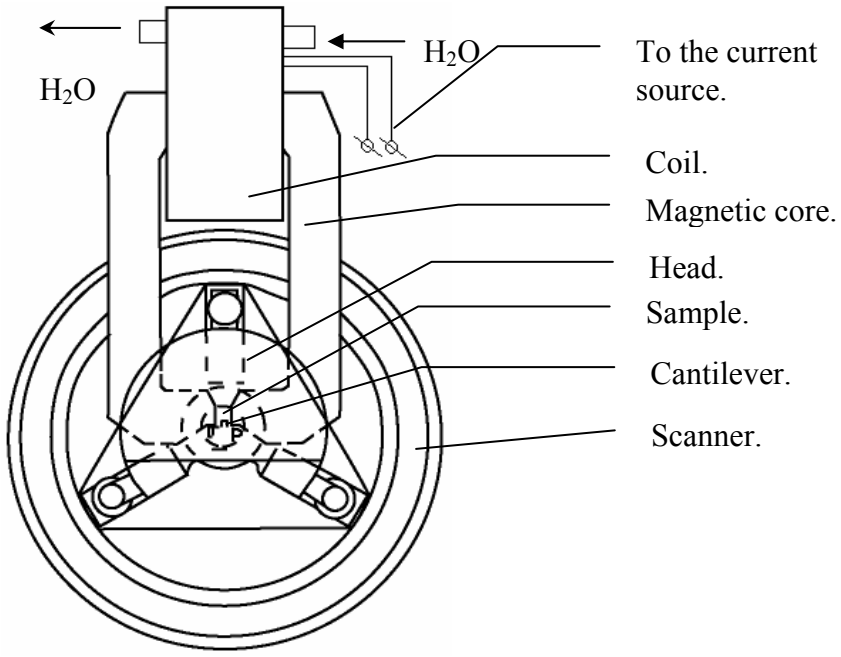

Fig.1 The magnetic microscope with an external magnetic field option.

The magnetic microscope with an external magnetic field option is shown in the figure 1. The magnetic field source involves a water-cooled coil including a controllable current source. The magnetic field is supplied to the sample with the help of a magnetic core.

The desired magnetic force microscope with an option of an external controllable magnetic field was applied to measure a local magnetization of the series of the samples, which include as the hard disk and the floppy disk demagnetization as a studying of permalloy structures with low coercetivity. The demagnetization process of the floppy disk is shown in the figure 2.

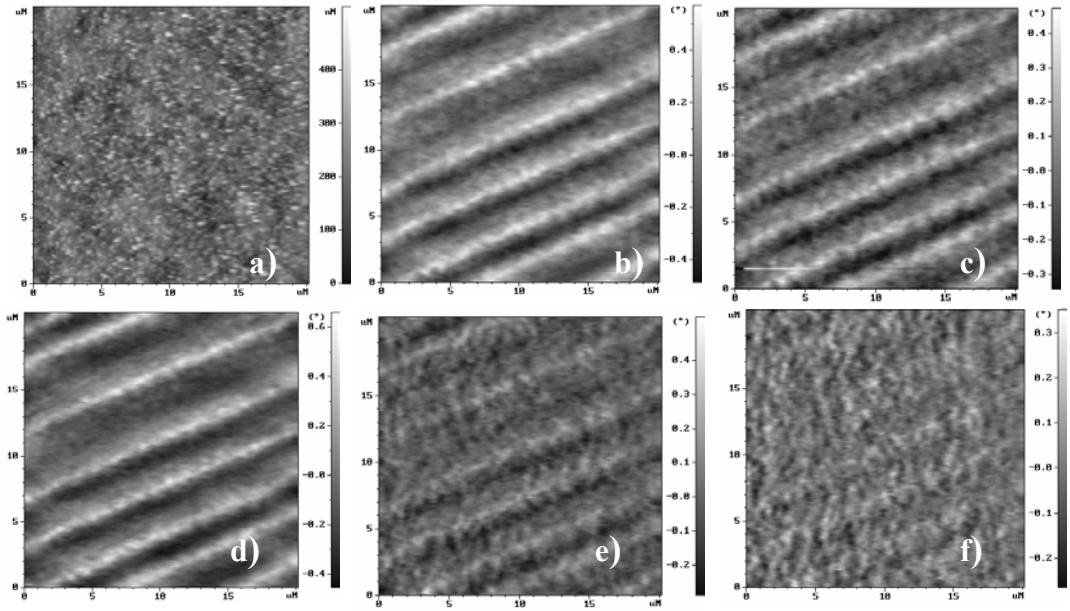

Fig. 2. The demagnetization of the floppy disk in an external magnetic field.
a) AFM image of the surface of the floppy ; b) magnetic contrast with H=0;
b) H=480 Oe; d) H=785 Oe; e) H=1080 Oe ; f) H=1340 Oe.

The magnetic contrast of permalloy nanostructures in an external magnetic field of various intensities is shown in the figure 3.

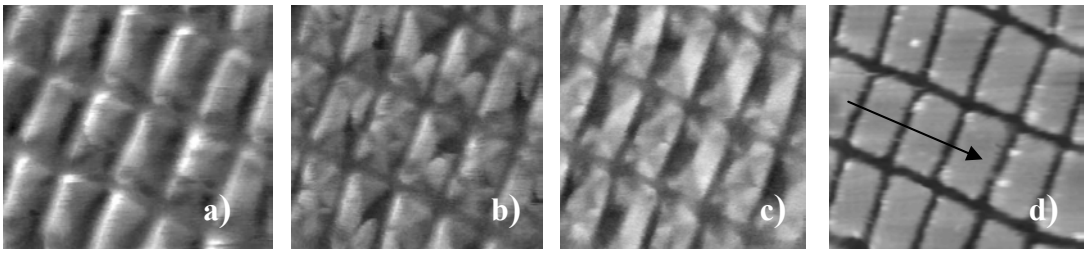

Fig. 3. The magnetic contrast of the permalloy structure of 1×2 μm and 50 nm thick rectangles. . a) H=-150 Oe; b) H=0; c) H=150 Oe; d) AFM image of the surface. The arrow indicates the positive direction of the magnetic field.

The changes of the domain structure in an external magnetic field were observable because the current source with a precise regulation of the current of the magnetic coil was used.

Thus the magnetic force microscope in an external controllable magnetic field has been desired and applied for investigation of a wide variety of magnetic structures.

1. P.Grutter, H.J. Mamin, and D.Rugar, Scanning Probe Microscopy II, New York, Springer Verlag (1991).
2. R. Proksh, E. Runge, P. K. Hansma, Sh. Foss and B. Walsh, J. Appl. Phys., **78,** 3303 (1995).
3. A.M.Alexeev, V.A.Bykov, A.F.Popkov, N.I.Polushkin, and V.I. Korneev, JETP Letters, Vol. **75**, No 6, p 268 (2002).