MAGNETIC FORCE MICROSCOPE USING CARBON NANOTUBE PROBES

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The development in magnetic devices such as HDD, MRAM and spin-electronics devices makes positive advances, on the bases of techniques of nanofabrication and thin-film growth. The magnetic characteristics of nanodevices depend on the surface structures and interfaces. In case of longitudinal magnetic recording media, the direction of the magnetic moment thermally fluctuates, when the size of the magnetic bit reaches down to nanometer range. To settle this problem, nano-magnets are set out perpendicular to the track plane in a perpendicular recording media which is expected as a future recording mode. Thus, the control of the magnetic domain structure and magnetization mechanism must be controlled for improving and maintaining the storage density. Lots of methods were applied and developed for observation of the magnetic domain structure with the high resolution, such as Lorentz electron microscopy, spin-polarized scanning tunnelling microscopy and magnetic circular-dichroism X-ray microscopy. Magnetic force microscope (MFM) is the most-often used method in the research and development of magnetic nanodevices, because of its convenience and the high resolution. It is in popular use for the evaluation of magnetic storage media and the observation of magnetic domains of thin-films. It is well known that the tip diameter strongly affects on the tip-sample interaction. Hence, decrease the tip diameter is the most significant method to improve the lateral resolution for the magnetic domain observation. Some methods were experimented for decreasing the tip diameter, such as acumination, reduction in the magnetic coat thickness, and utilization the carbon nanotube probes [1,2]. As results of these efforts, the lateral resolution reached to less than 20 nm [3]. Considering the future progress in nanodevices, much higher resolution is required to evaluate various nano devices, *e.g.*, recording media with a density of Tbit/inch^2 (< 15 nm in bit length).

In this report, we show the MFM observation of ultra-high-density perpendicular magnetic storage media. The lateral resolution is largely improved using a CNT probe. The magnetic recording with densities from 600 to 1100 k flux change per inch in a perpendicular magnetic storage media were clearly observed. The ultimate lateral resolution is about 10 nm. It is demonstrated that the effectiveness of the predicted CNT probes with magnetic coating in MFM measurements.

References:

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[2] T. Arie, H. Nishijima, S. Akita and Y. Nakayama, J. Vac. Sci. Technol. B**18**, 104 (2000).
[3] T. Yamaoka, K. Watanabe, Y. Shirakawabe and K. Chinone, J. Magn. Soc. Jpn. **27**, 429 (2003) (in Japanese).

Figures:

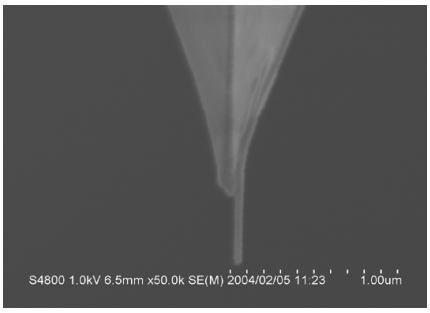

Figure 1 An SEM image of a CoFe-coated CNT probe.

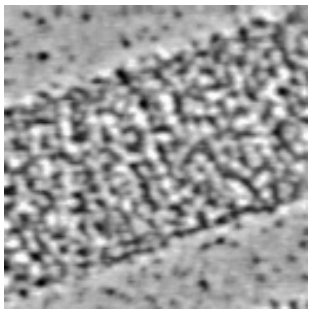

Figure 2 An MFM image (1x1 μm) of an area of ultra-high-density recording media (1100 kFCI).