High-frequency MFM characterization of magnetic recording writer poles

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A high-frequency MFM (HF-MFM) is built up for the observation of the high-frequency stray fields of harddisk write heads, using a commercial AFM/MFM system as a basis. The HF-MFM technique was already described by several authors [1-3], employing different approaches to image the time-averaged head fields. In this contribution, we employ the amplitude-modulation technique, where an amplitude-modulated current was applied to the head coil in order to detect the force gradient induced by the HF magnetic field. We further still use the piezo element to vibrate the cantilever, so that a dual-vibrational technique results. Here, the cantilever is oszillated by the piezo element *and* the HF magnetic field from the writer pole. Figure 1 presents a schematical drawing of the HF-MFM setup.

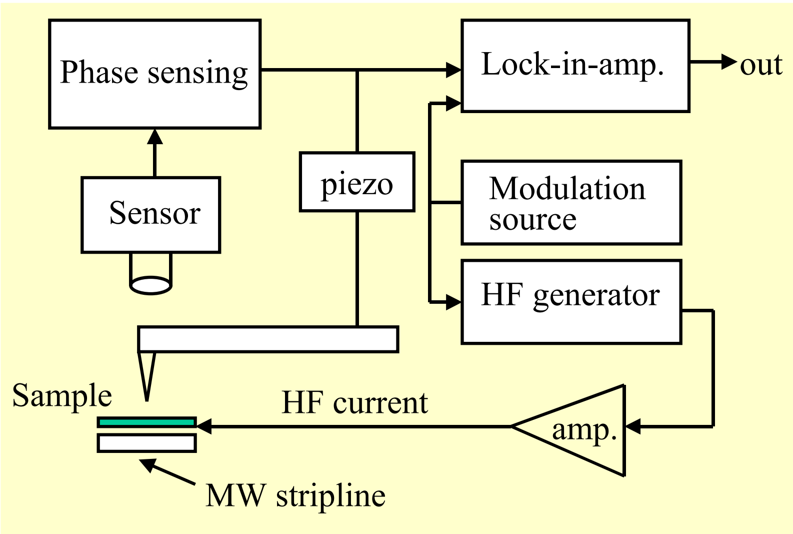

Fig.1 Schematical drawing of the HF-MFM setup.

Also foreseen is a microwave stripline, which may carry a high-frequency magnetic field, so that also standard magnetic materials may be imaged, not only harddisk writer poles.
The achieved spatial resolution is comparable to that of standard MFM. When using advanced MFM cantilevers fabricated by means of focused-ion beam milling, the resolution can be increased towards the 20 nm range. This treatment yields a high-aspect ratio tip [4], and a 10 nm coating with CoCr is applied. In this way, high-resolution, low-moment MFM tips are batch-prepared.
Dynamic HF magnetic fields emerging at the poles of the write heads were clearly imaged; especially along the P2 pole shape on the air-bearing surface. Recent harddisk write poles have overall dimensions of some micrometers in length, but only a width of ~300 nm. For the present measurements, harddisk writer poles stemming from SEAGATE were employed. Figure 2 presents the results obtained at two different frequencies, 500 MHz and 1000 MHz, and also as 3-dimensional views. At 1000 MHz, the field directly at the gap is dominating, while the fields along the downtrack direction decrease. The frequency dependence of the head-field distributions were measured up to 2 GHz using CoCr-coated MFM cantilevers. In Fig. 3, we show the profiles taken along the downtrack direction for different applied frequencies.

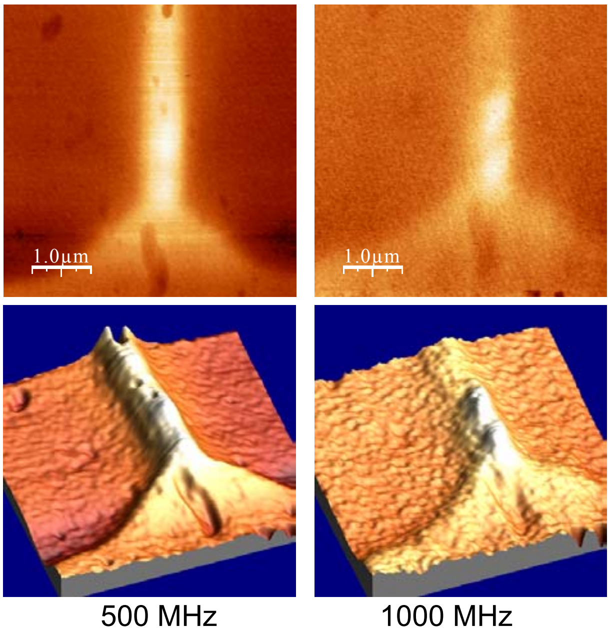

Fig.2 Writer pole field distributions measured by HF-MFM at two different frequencies.

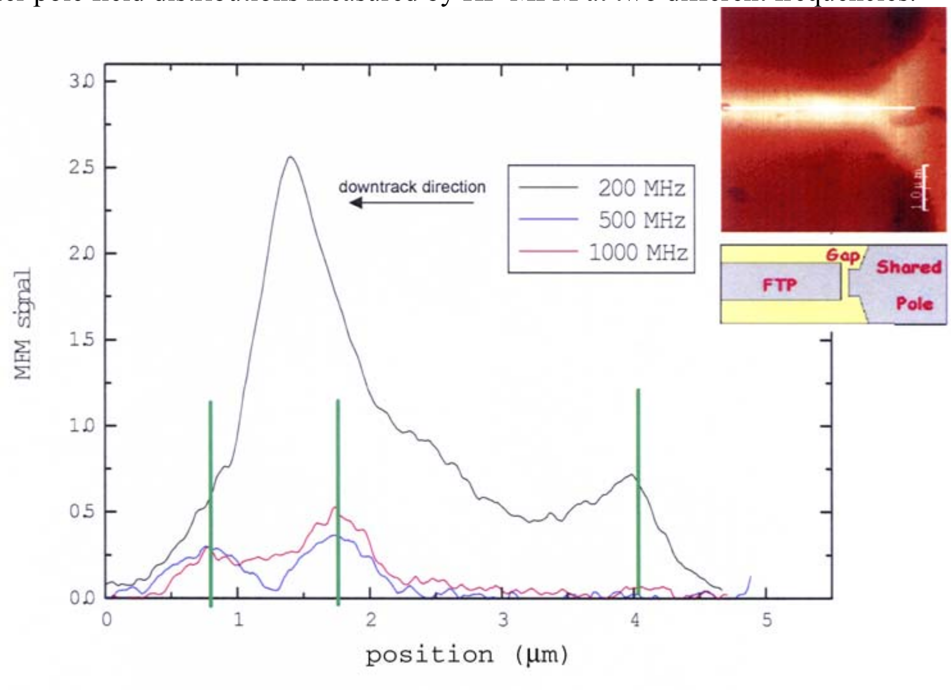

Fig.3 Head field distribution of the pole tip along downtrack direction at different frequencies.

From these measurements, one can deduce that the dual-vibrational detection technique is the optimum condition for the HF-MFM technique, enabling a spatial resolution down to the 20 nm range at ambient conditions like in standard MFM.

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References

[1] R. Proksch, P. Neilson, S. Austvold and J. J. Schmidt, Appl. Phys. Lett. 74, 1308 (1999).
[2] M. Abe and Y. Tanaka, J. Appl. Phys. 89, 6766 (2001).
[3] S. Li, S. Stokes, Y. Liu, S. Foss-Schrader, W. Zhu, and D. Palmer, J. Appl. Phys. 91, 7346 (2002).
[4] M. R. Koblischka, U. Hartmann, T. Sulzbach, J. Magn. Magn. Mat. 272-276, 2138 (2004).
[5] M.R.Koblischka, U. Hartmann, T. Sulzbach, Mat. Sci. Eng. C 23 (2003) 747.