A versatile variable field module for scanning probe microscopy measurements

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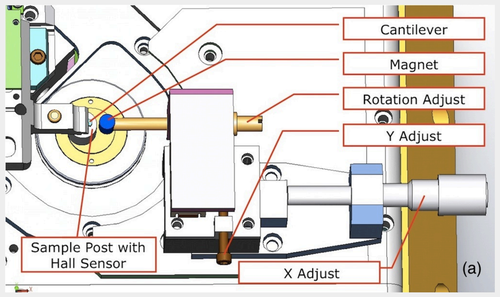
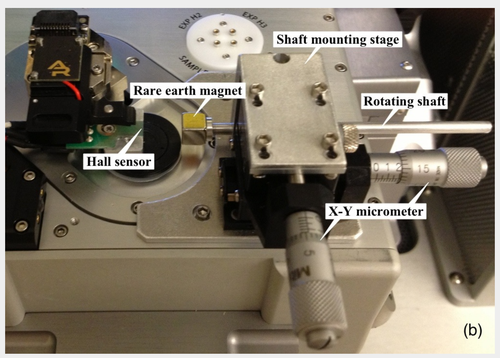
Introduction

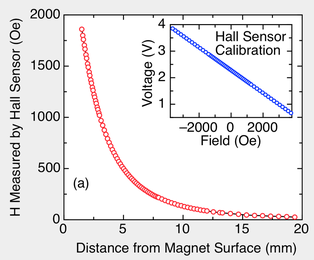
- Scanning probe microscopy has become one of the most important techniques for imaging and measuring matter at the nanoscale.
- Studying materials under magnetic field at the nanoscale is not only important for the understanding microscopic nature of their properties, but also essential for potential applications.
- We demonstrate a versatile variable field module for both field and angular dependent scanning probe microscopy measurements

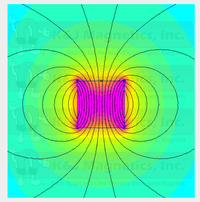
System Design



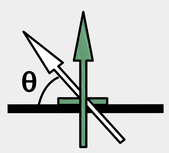


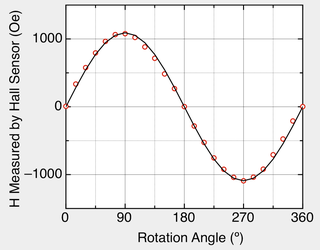
Field Calibration



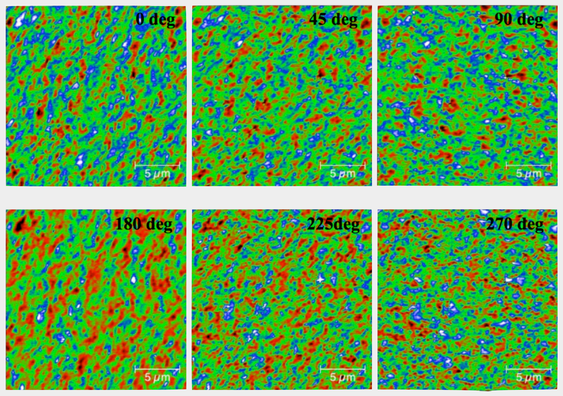


$H_{measure} = H \times \sin\theta$





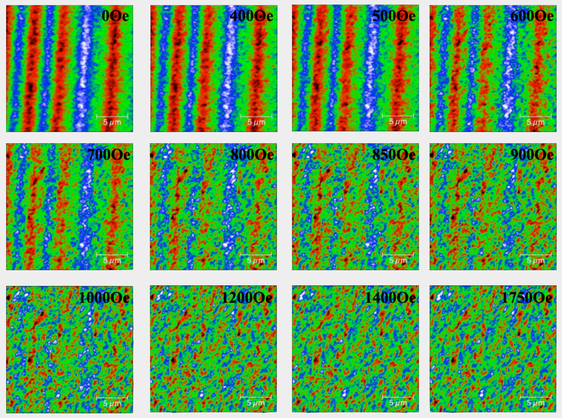
Angular Dependence



- Evolution of magnetic domain structures under fields with different rotating vector angles
- A completely reversible MFM phase contrast is observed when the magnetic field is rotated by 180°

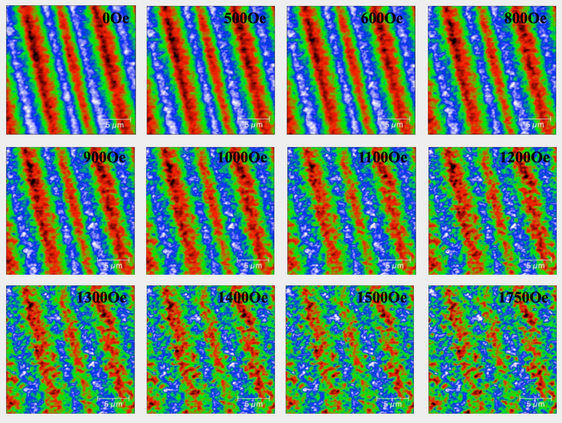
Field Dependence

Degaussing of floppy disk media – in-plane



- Stripe contrast starts to disappear with increasing in-plane magnetic fields, indicating that the magnetic bit profile is progressively destroyed.

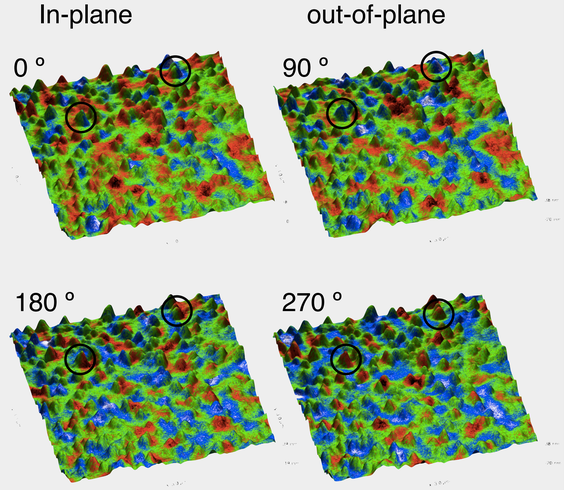
Degaussing of floppy disk media – out-of-plane



- Written bits are erased at a much slower rate with increasing out-of-plane magnetic fields due to the in-plane magnetic anisotropy.

$CoFe_2O_4$-$BiFeO_3$ composite

$CoFe_2O_4$ magnetic nanopillars embedded in ferroelectric $BiFeO_3$ matrix



- Some $CoFe_2O_4$ pillars (marked in circle areas) show clear signs of switching to either in-plane or out-of-plane dependent on the applied field vector directions.

Summary

- We demonstrate a versatile variable field module design for Asylum Research Cypher AFM, with the capability of both field and angular dependent measurements.
- The capability of the VFM system were successfully demonstrated by degaussing a floppy disk media and by studying the magnetic switching in a $CoFe_2O_4$-$BiFeO_3$ nanocomposite.

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