Introduction

The **Variable Field Module** (VFM3) is an ideal option for researchers who want to apply high magnetic fields to their atomic force microscopy experiments.

Asylum Research has developed a second generation Variable Field Module (Figure 1) for the MFP-3D™ Atomic Force Microscopes (AFM). This module is useful for magnetic force microscopy (MFM), conductive AFM (C-AFM), and other applications where the sample’s properties are magnetic field dependent. The VFM3 can apply static magnetic fields up to ±0.8 Tesla (~1 G resolution), parallel to the sample plane.

How it Works

The VFM3 has a unique design incorporating a motor driven permanent magnet. Figure 2 shows how the rotation of a powerful rare earth magnet translates into a variable field at the sample. Once a field value is reached, the motor is turned off and the field is maintained without residual heat, thermal drift, or mechanical vibration.

Features

The VFM3 attaches to the MFP-3D XY sample scanner by means of the included quick release plate. Adjustable pole pieces allow for optimal choice between maximum required field, sample placement and minimum field gradients. Field intensity is software controllable. An integrated Hall sensor provides a quantitative measure of the applied magnetic field and closed loop feedback control between motor and sensor allow for linear field ramps. A beryllium copper non-magnetic cantilever clip that minimizes field distortion is included.

Application Examples

The image sequence in Figure 3 shows the application of an increasing magnetic field to a piece of PMR (Perpendicular Magnetic Recording) hard disk. The written bits are progressively degaussed as the in-plane magnetic field is increased from zero to >0.7 Tesla.

Figure 4 presents MFM phase images of a Terfenol-D disk with and without fields applied perpendicular to the magnetization. Figure 4(a) and 4(b) show the MFM phase signal with an applied 2000G field and after the field is removed, respectively. Figures 4(c) and 4(d) similarly show phase images with and without a -2000 G field.

Optional High Voltage Tip Bias

For experiments where combined magnetic field and a high tip-sample voltage bias are required, such as for studies of ferroelectric and piezoelectric materials, the VFM3 HV Kit can be attached to the module with a few screws (Figure 5).
The VFM3 HV Kit also requires an MFP-3D AFM upgraded with the High Voltage Option, which includes:
- LFM head
- High voltage sample holder
- High voltage cantilever holder
- HV220 high voltage amplifier

**VFM3 Specifications**
- Maximum field: ±0.8 Tesla
- Maximum field ramp: 7000 G/minute
- Sensor resolution: ~1 G
- Closed loop control minimum increment: ~1 G
- Open loop minimum step: ~0.2 G
- Other environmental conditions: Ambient

Figure 3: Five frames showing a piece of PMR hard disk degaussed with an in-plane ~0.7 Tesla magnetic field using the VFM3.

Figure 4: MFM phase images of the Terfenol-D disk under a series of in-plane fields perpendicular to the magnetization. (a) MFM phase images taken at 2000 G and (b) after field removal; (c) MFM phase images taken at -2000 G and (d) after field removal. The direction of the magnetic field is indicated by the arrow. 10 μm scan. Image courtesy of Shuhong Xie, Xiangtan University, China and JiangYu Li, University of Washington.

Figure 5: VFM3 with High Voltage Unit attached.

Visit [www.AsylumResearch.com](http://www.AsylumResearch.com) to learn more