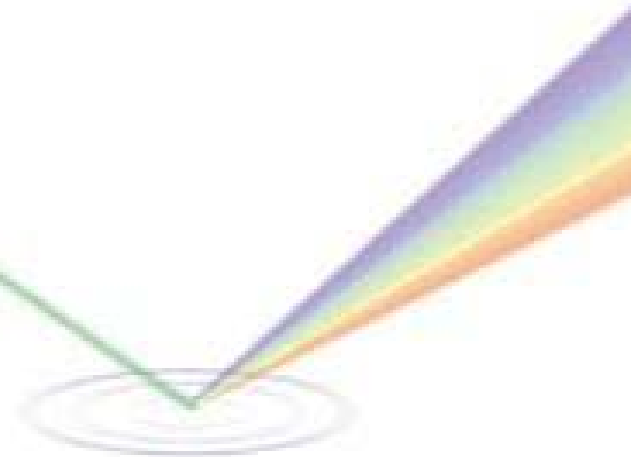


Advances in Thin Film Metrology for MRAM

by
Mark Willingham
ADE Corporation



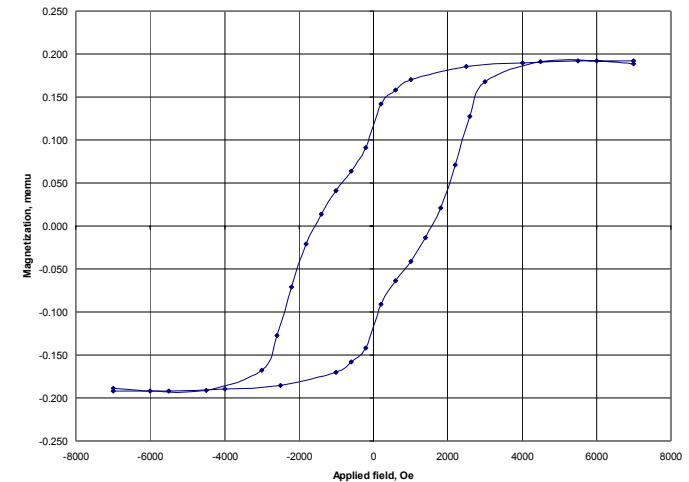
Thin Film Metrology for Magnetic Measurements

- What's Available – Limitations?
 - ◆ Absolute Measurement
 - ◆ Mapping
- Process Metrology used in GMR today
- Challenges of MRAM for Metrology
- Current MRAM Metrology

Magnetics to Absolute Ref

Vibrating Sample Magnetometer

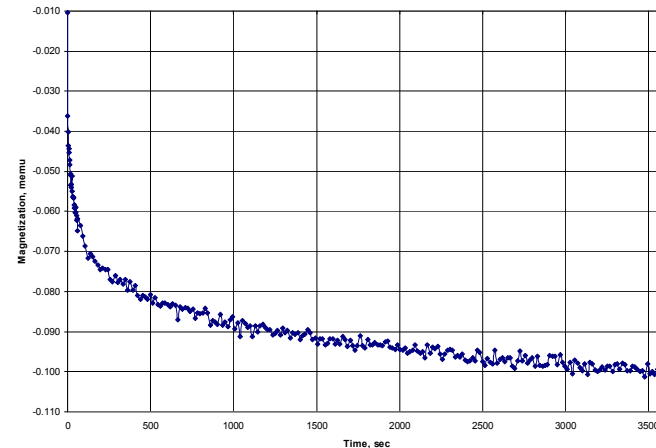
- ◆ 1×10^{-7} emu Sensitivity
- ◆ High Precision Vector performance
- ◆ Direct field control - Speed
- ◆ Versatile, Sophisticated software
- ◆ Temperature available
- ◆ Absolute Moment measurement
- ◆ Sample size limited to ~8mm



Magnetics to Absolute Ref

SQUID

- ◆ 1×10^{-9} emu Sensitivity
- ◆ High Stability
- ◆ Helium Temperature range
- ◆ Very Slow measurement
- ◆ Sample size limited



AGFM

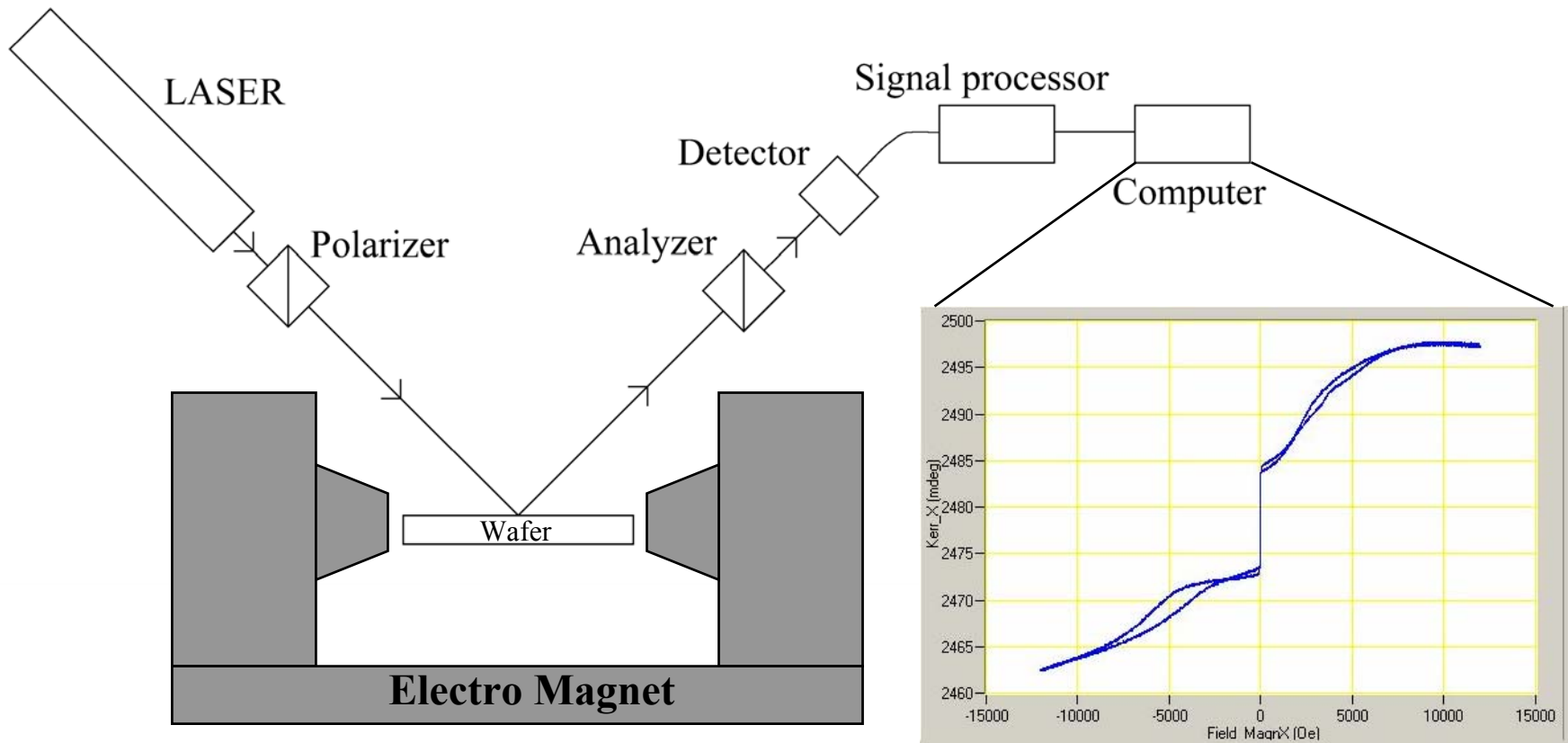
- ◆ 1×10^{-8} emu Sensitivity
- ◆ No Temperature capability
- ◆ Fragile in use
- ◆ Sample size limited

Not Enough, Need More!

Development and Production

- Wafer Level measurement
 - ◆ Need to Map
 - ◆ Eliminate Cutting
- Measure on Product
 - ◆ Non Contact
 - ◆ High Speed - Keep up with production
- Combine Measurement Needs
- Ready for Fab – Use in Clean room

Kerr Effect Measurement (Longitudinal)



Kerr Effect Measurement

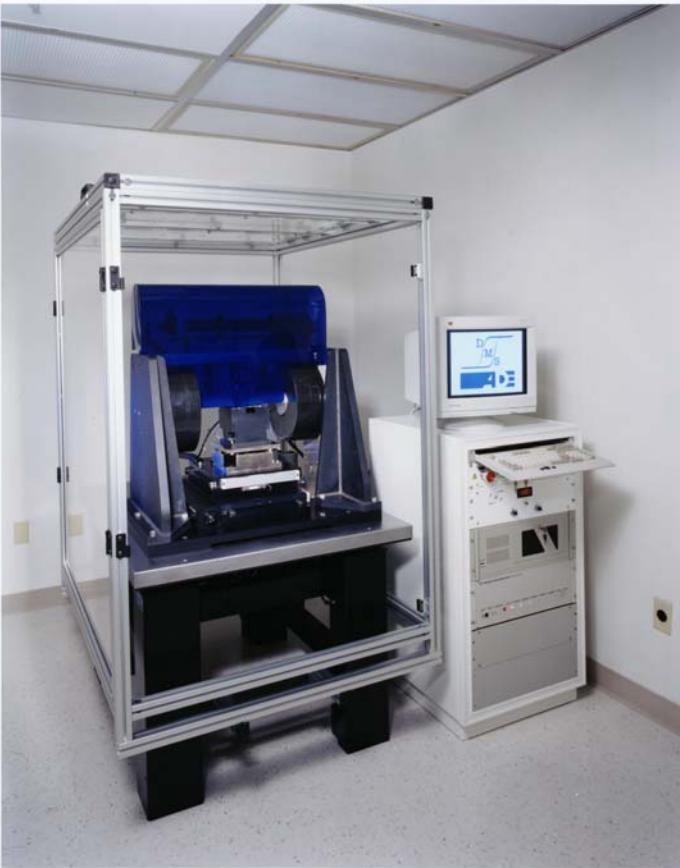
- Magneto optic – Non Contact
- No sample size limitation
- Spot measurement on wafer
- See multiple interacting layers

- Penetration depth limited
- No absolute layer thicknesses
- Small Signal available
- Environmental sensitivity

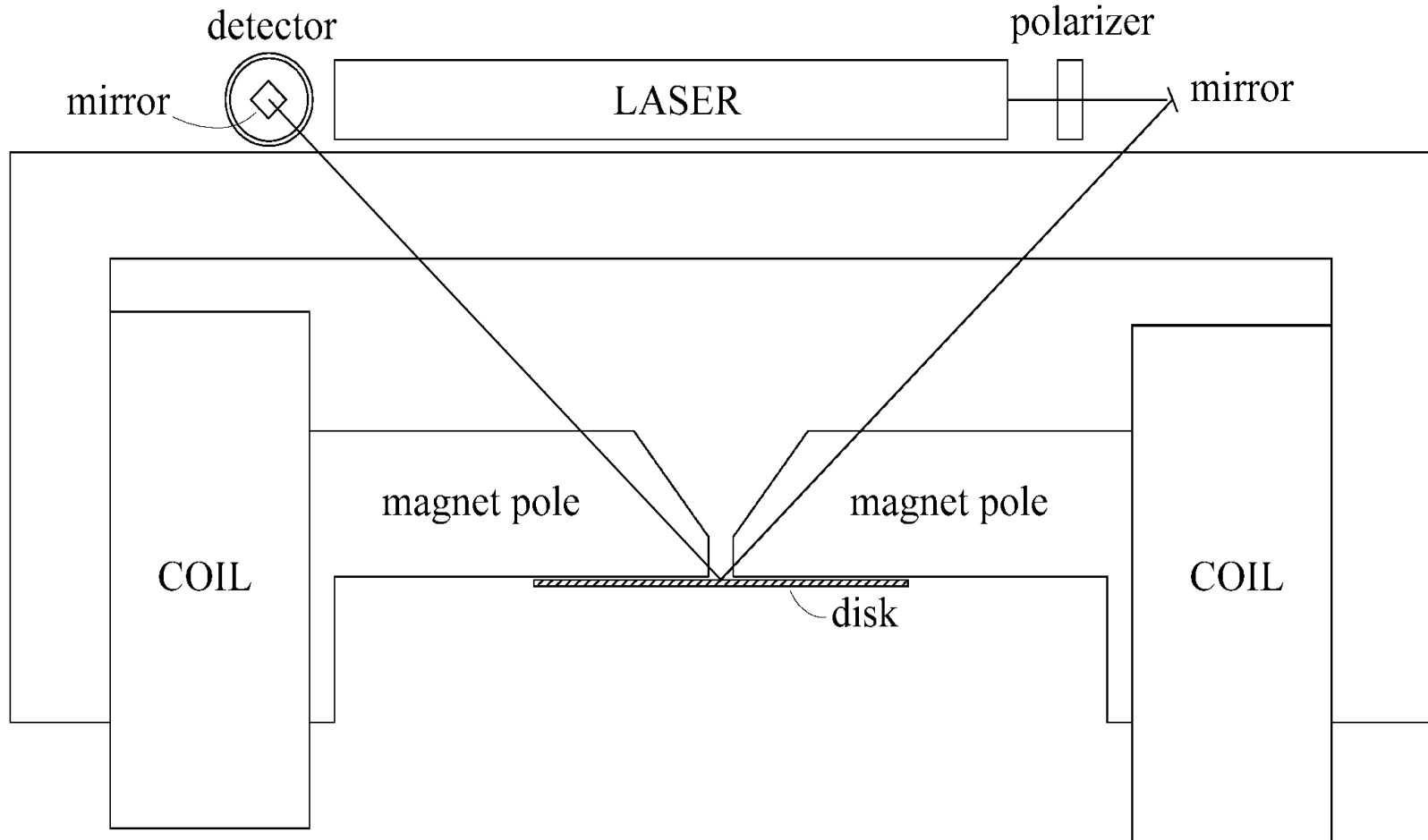
Kerr Effect Magnetometer

Used in GMR process

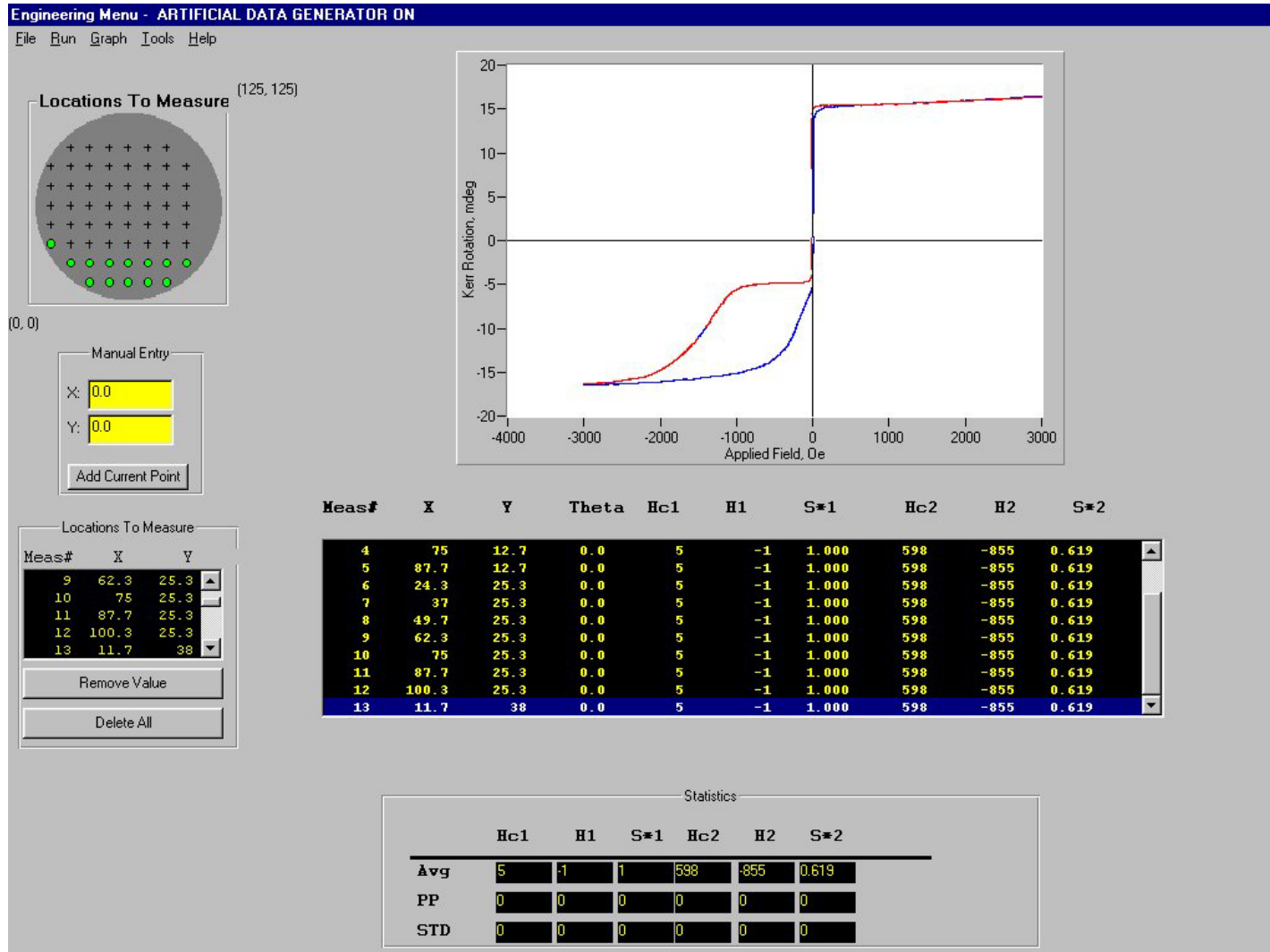
- Non-contact measurement of magnetic parameters
- Single point or multi-point
- High Field up to 12,000 Oe
- High Resolution - 0.01 Oe
- Fast - 10 seconds per measurement



Layout of Kerr Effect Magnetometer



Need Strong Interface

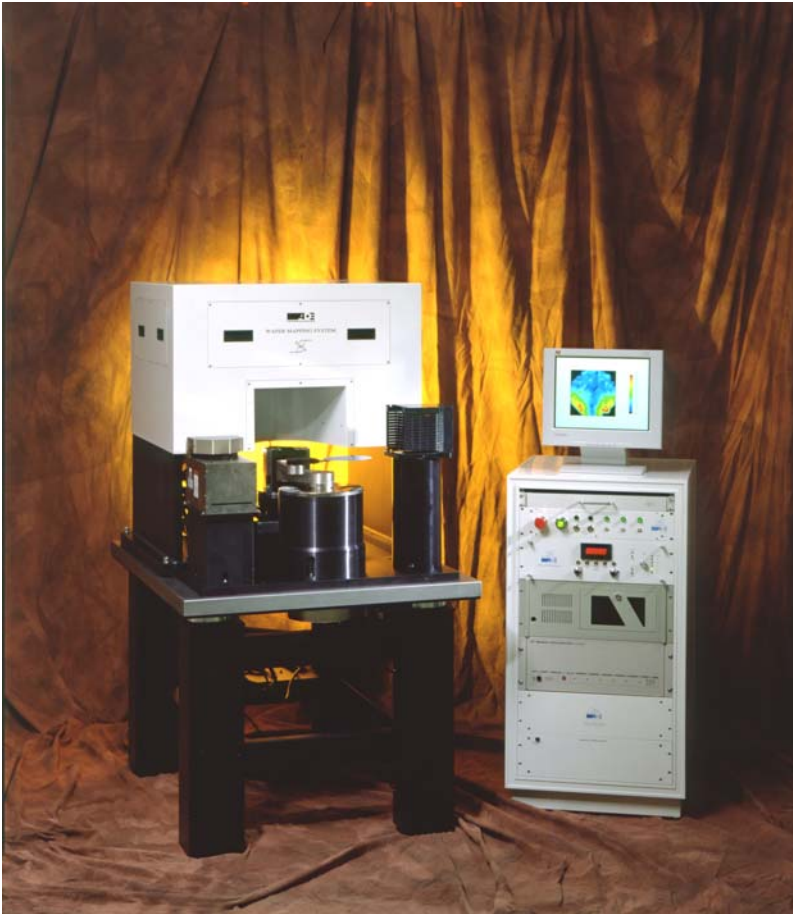


MRAM Metrology

New Challenges for Kerr

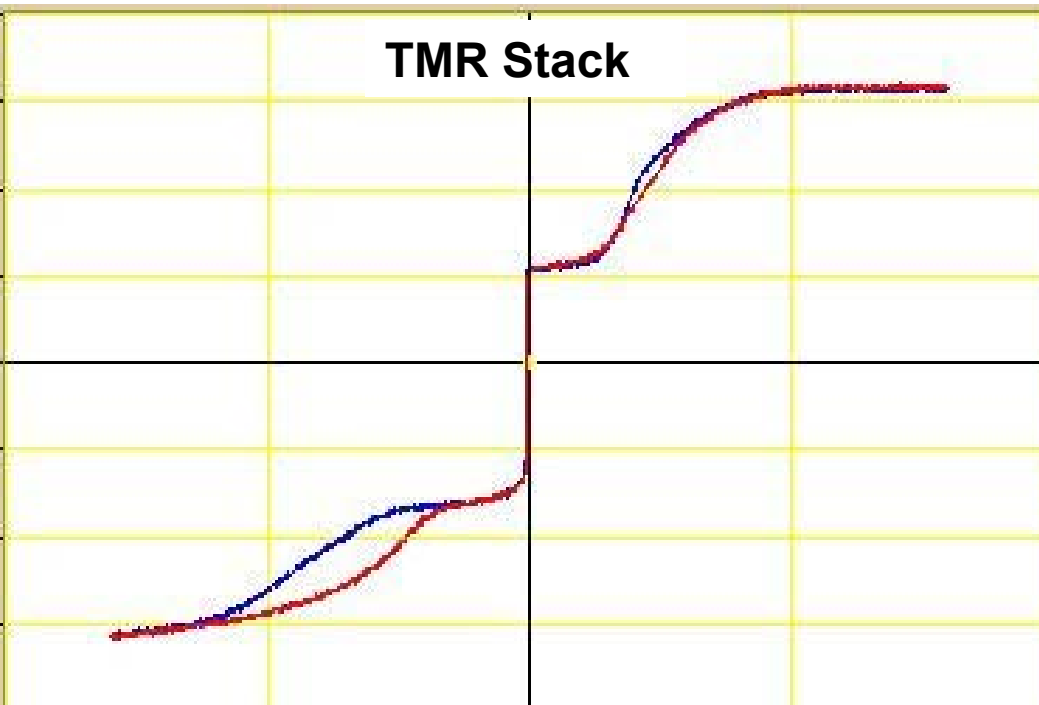
- New Processes
- Active Field Control
 - ◆ High Field w/ Low Field Resolution
 - ◆ Free and Pinned layer
- Multi Axis Field
- Thinner Layers
- Small Packing Ratio
- Additional Top Layers
- Substrate Size Increasing?

Kerr Effect Magnetometer for MRAM



- Full Wafer Access up to 300 mm
- Non Contact
- Active Field Control
- Proven Technology
- Vector Field Capable
- Vector Kerr

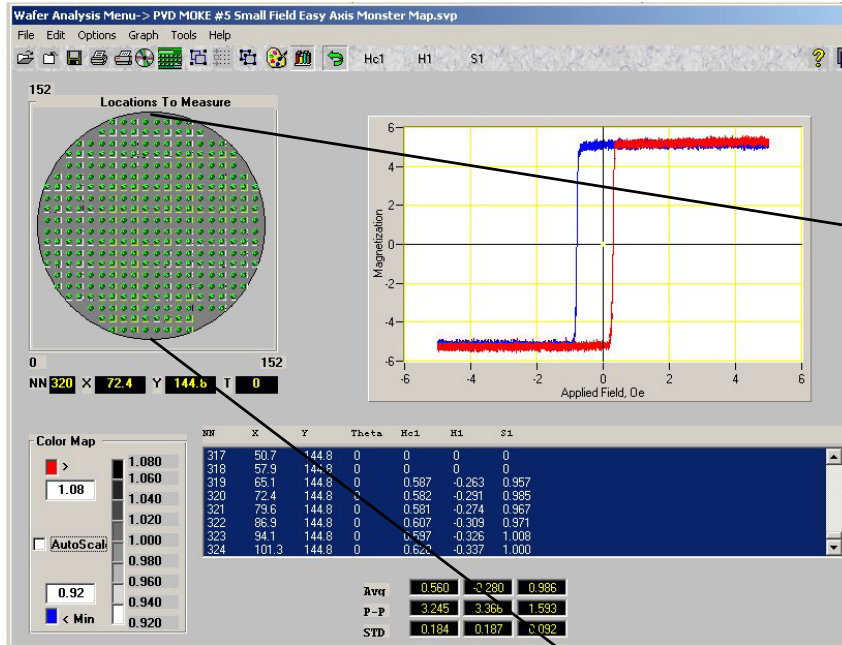
Kerr Effect Magnetometer for MRAM



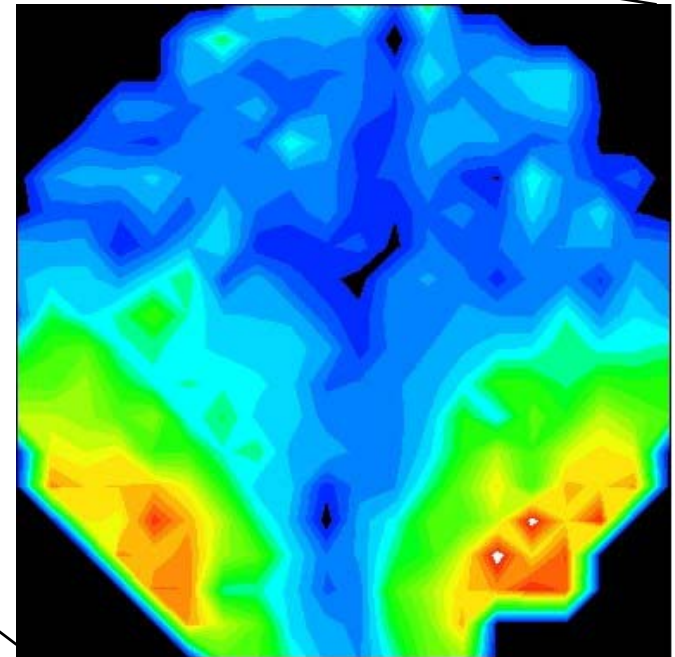
Set High Field

- ◆ Excite both Free and Pinned Layers to see Interaction
- ◆ Penetrate Multiple layers

Uniformity of Sheet Film

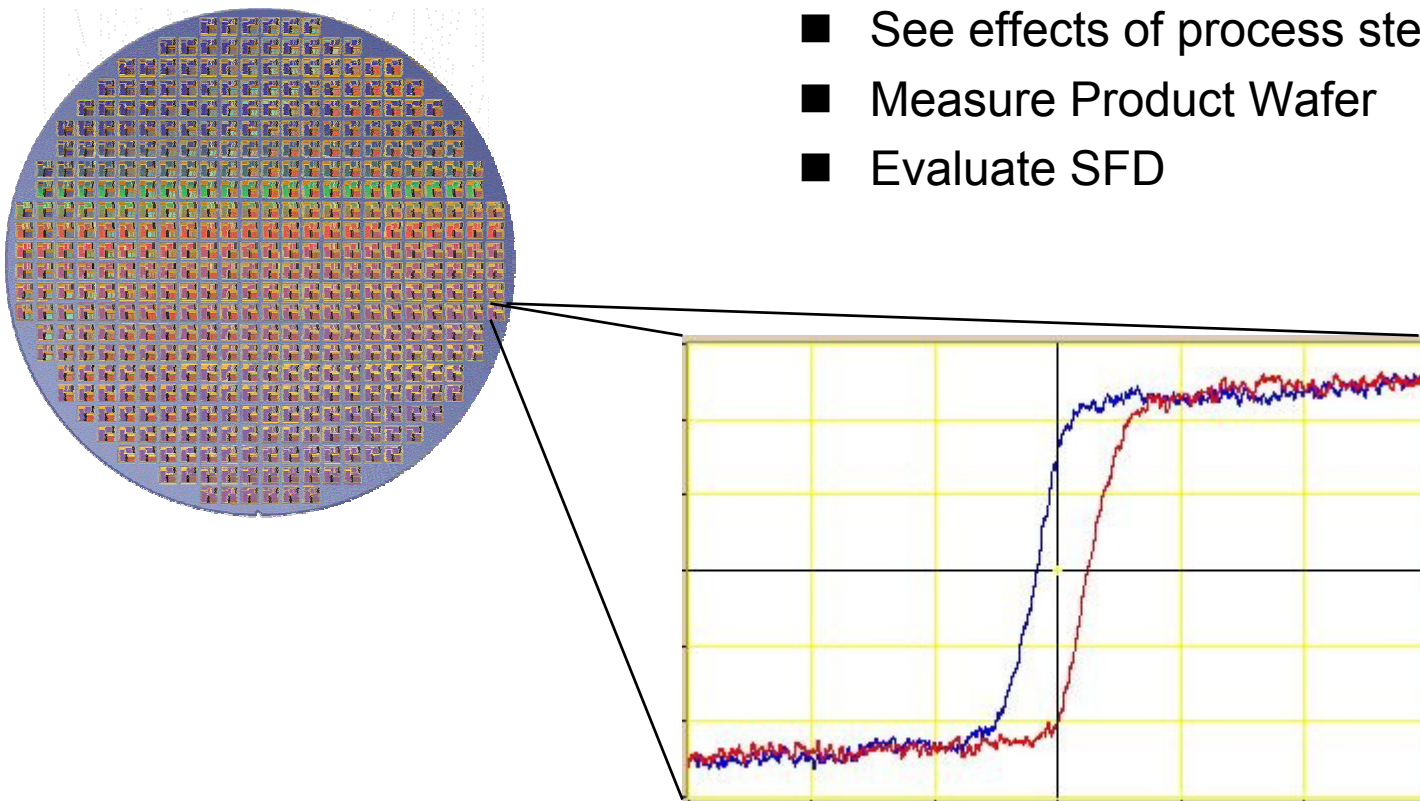


- Low Field Accuracy
- Immediate Feedback
- Monitor key parameters

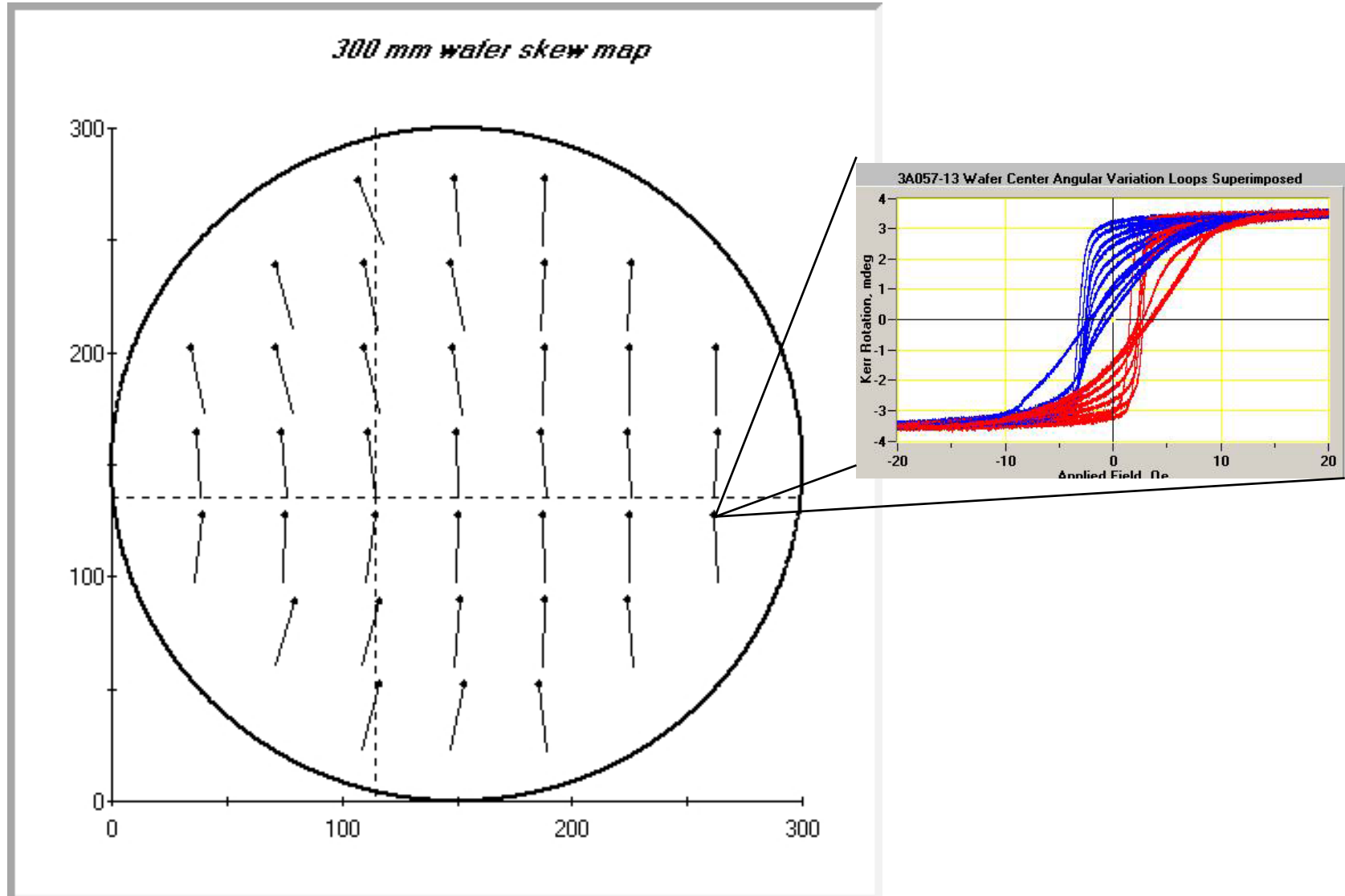


Scan Patterned MRAM Array

- Signal << sheet film
- See effects of process steps
- Measure Product Wafer
- Evaluate SFD



Evaluate Angular Properties



MRAM Kerr Effect Magnetometer

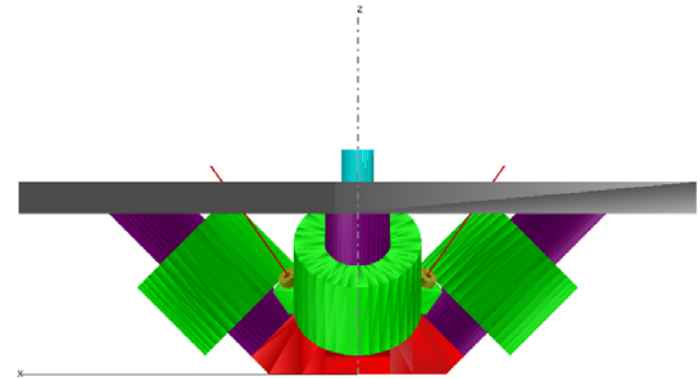
Operation

- ◆ Load wafer by hand or Robot
- ◆ Auto Z Position - Cap gage Feedback
- ◆ Measure Selected Locations
- ◆ Extract Parameters
- ◆ Access whole wafer
- ◆ User Defined Mapping
- ◆ Modular Design



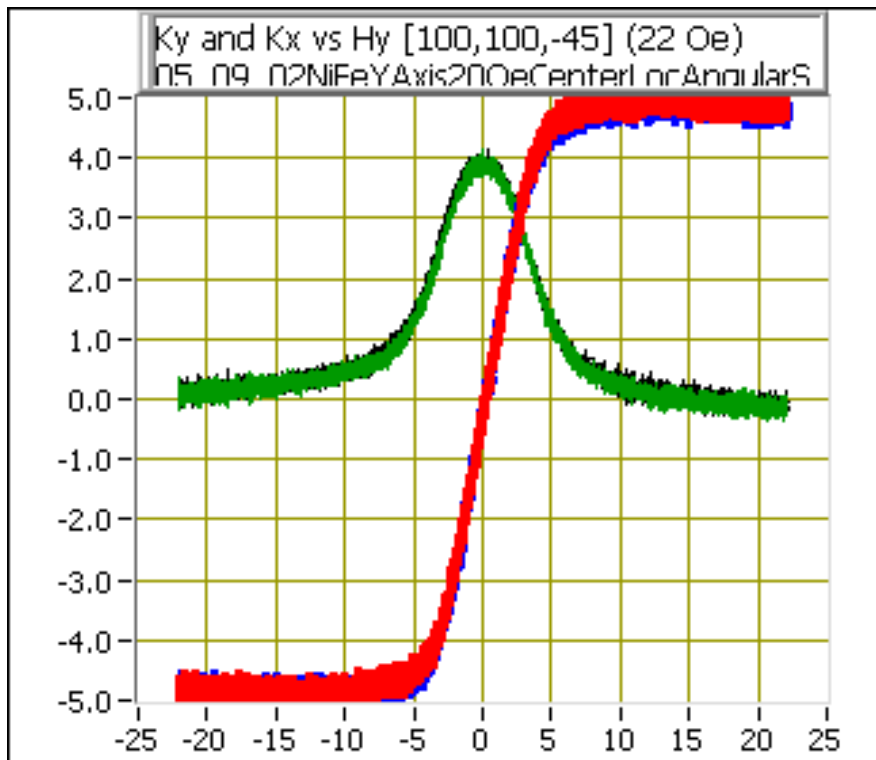
Active Field Control

- **Active Control = True Zero Field**
 - ◆ Hall Probe Feedback
 - ◆ Pole Remanence
 - ◆ Earth field
 - ◆ Other stray fields
- **Real Time Feedback**
 - ◆ Static
 - ◆ Sweeping
- **Programmable Sweep Rate**

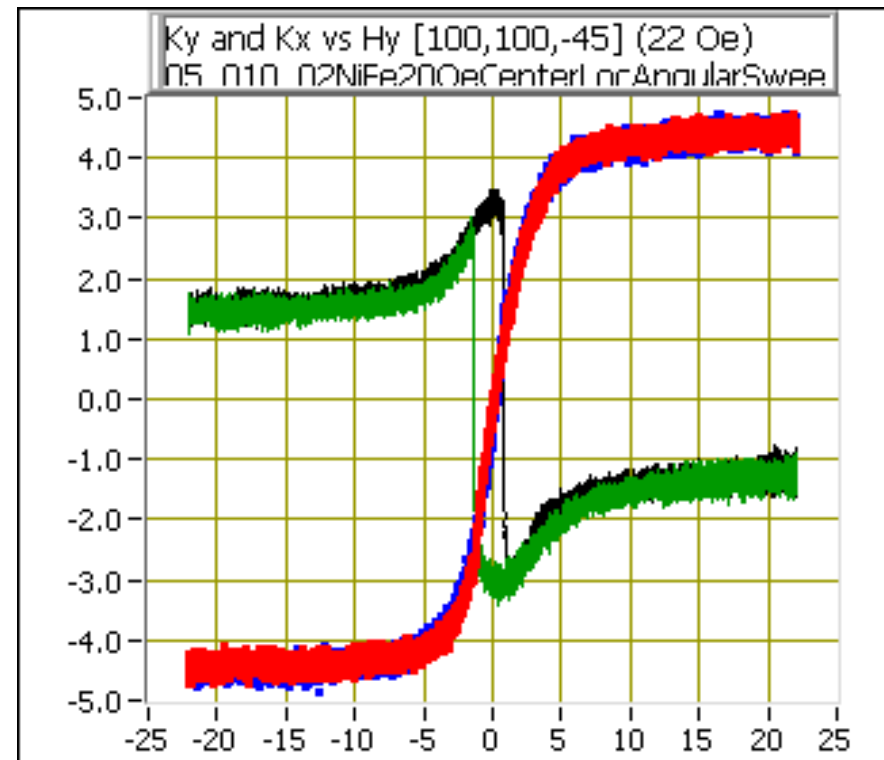


Vector Kerr

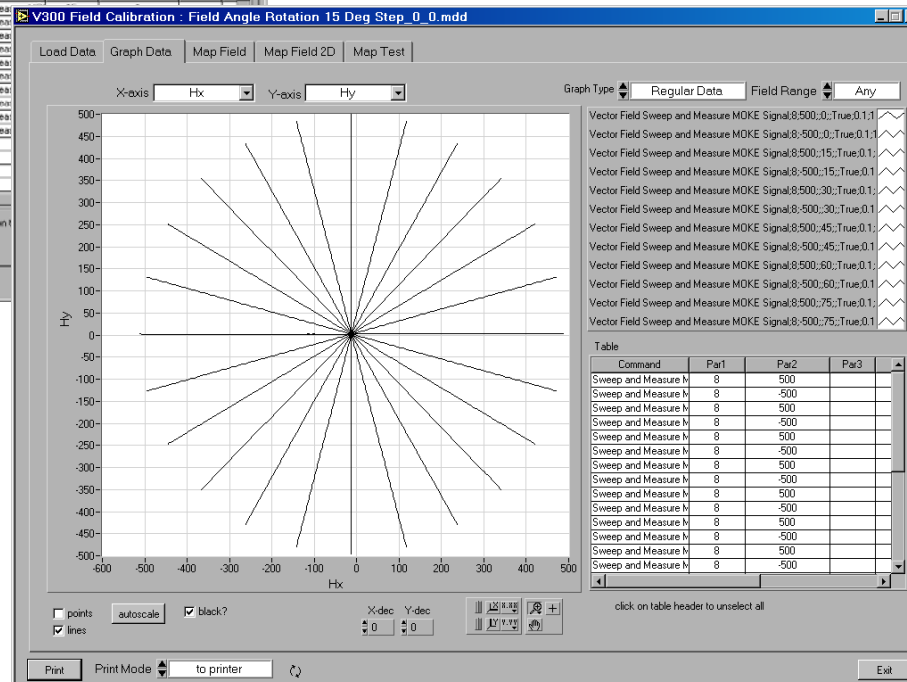
1 Oe Cross Field



Active Field Control



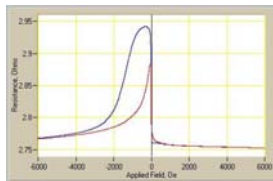
- Set field in any direction
- Apply Cross field
- No Remanence



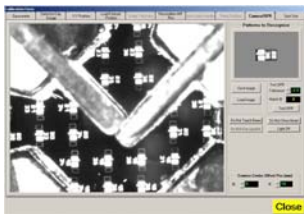
Supports multiple functions

Wafer Measurement Platform

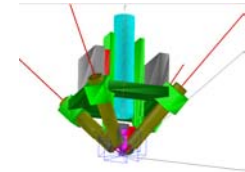
4 Point Probing Module



Test Pad Probing Module



Kerr Effect Module



Vector Field



Wafer Automation



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