What's Hot in Heat Assisted Magnetic Recording (HAMR)

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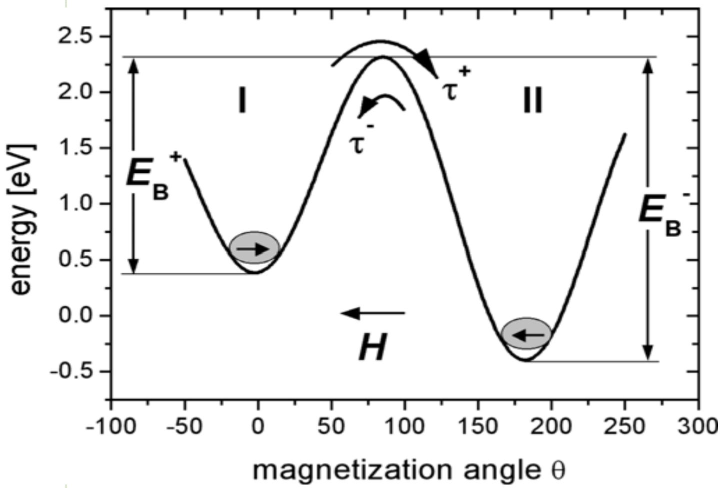
Outline

- Why HAMR?
- What is HAMR?
- Integrated HAMR Head Design & Challenges
  - Optical Field Delivery
  - Integration of Optical & Magnetic Field Deliveries
- Integrated HAMR Head Characterization
  - Optical Microscopy
  - Spin-Stand
- Future HAMR Prospects
- Conclusion

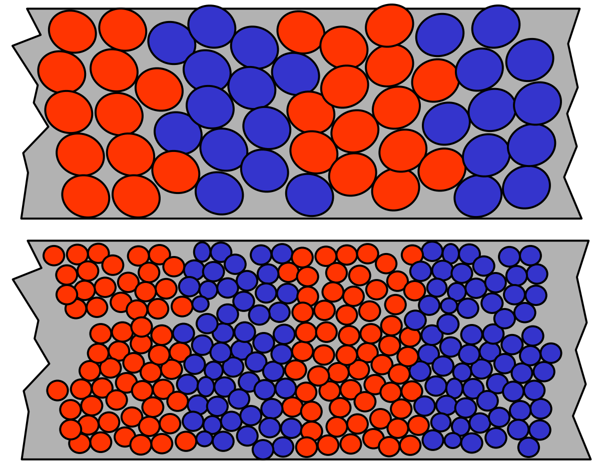
The Fundamental Problem

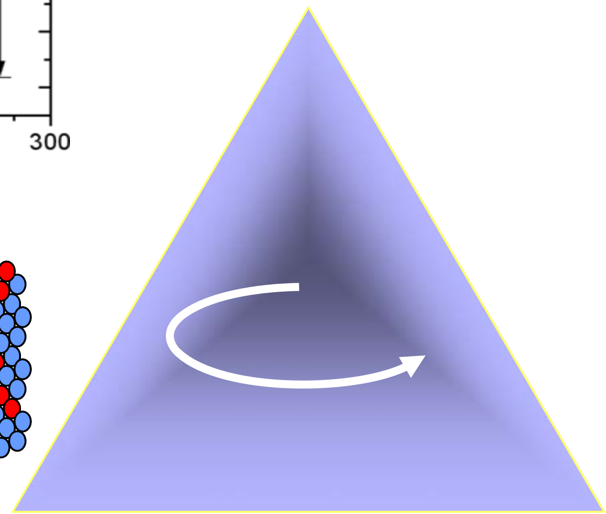


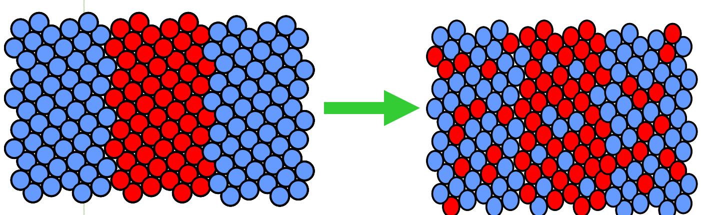
Media SNR

SNR~$\log_{10}$(N)

Small Grains (V)







Thermal Stability

$$E_B \cong K_u V \cdot \left[1 - \frac{H_d}{H_0}\right]^{3/2}$$

K_uV = 40-60 k_BT

H_0 < Head Field

Writability

$$H_0 = \alpha \cdot \frac{2 \cdot K_u}{M_S} - \underbrace{N_{eff} \cdot M_S}_{H_d}$$

Seagate

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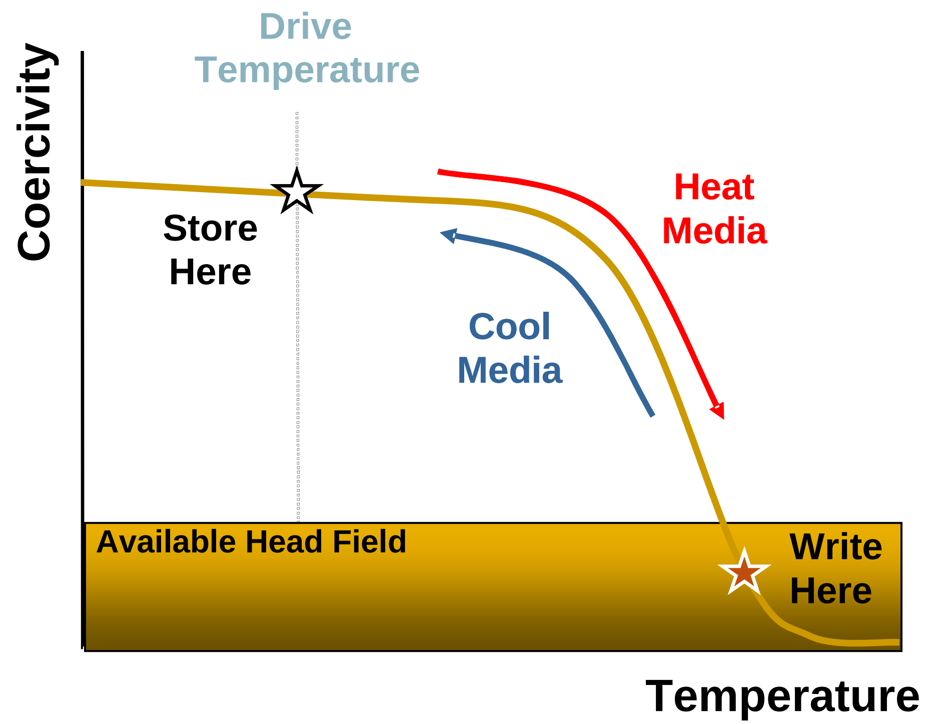
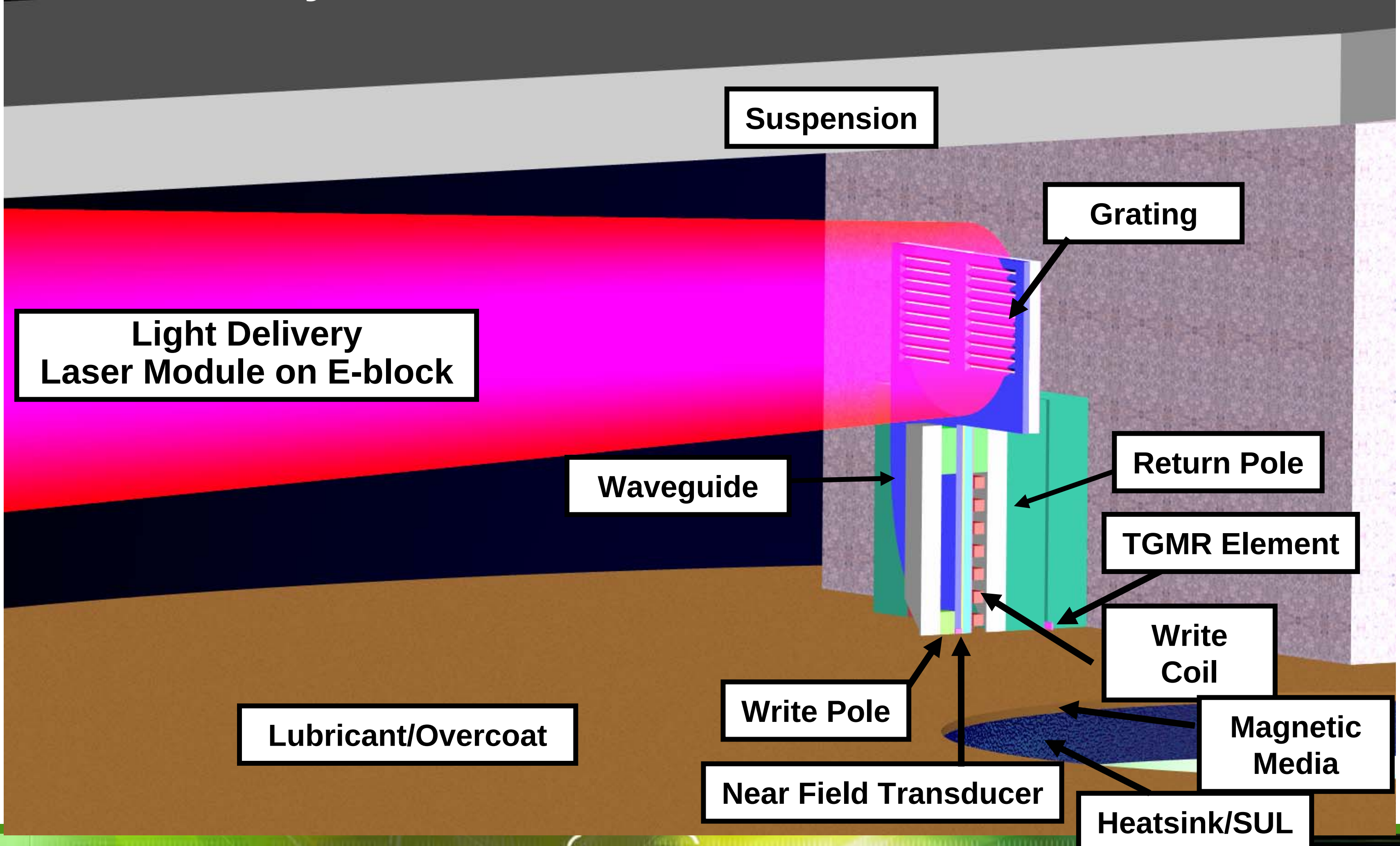
Writability with High Anisotropy Media

With HAMR

- we can write on high anisotropy media
- maintain thermal stability with reduced grain size
- extend the areal density growth curve



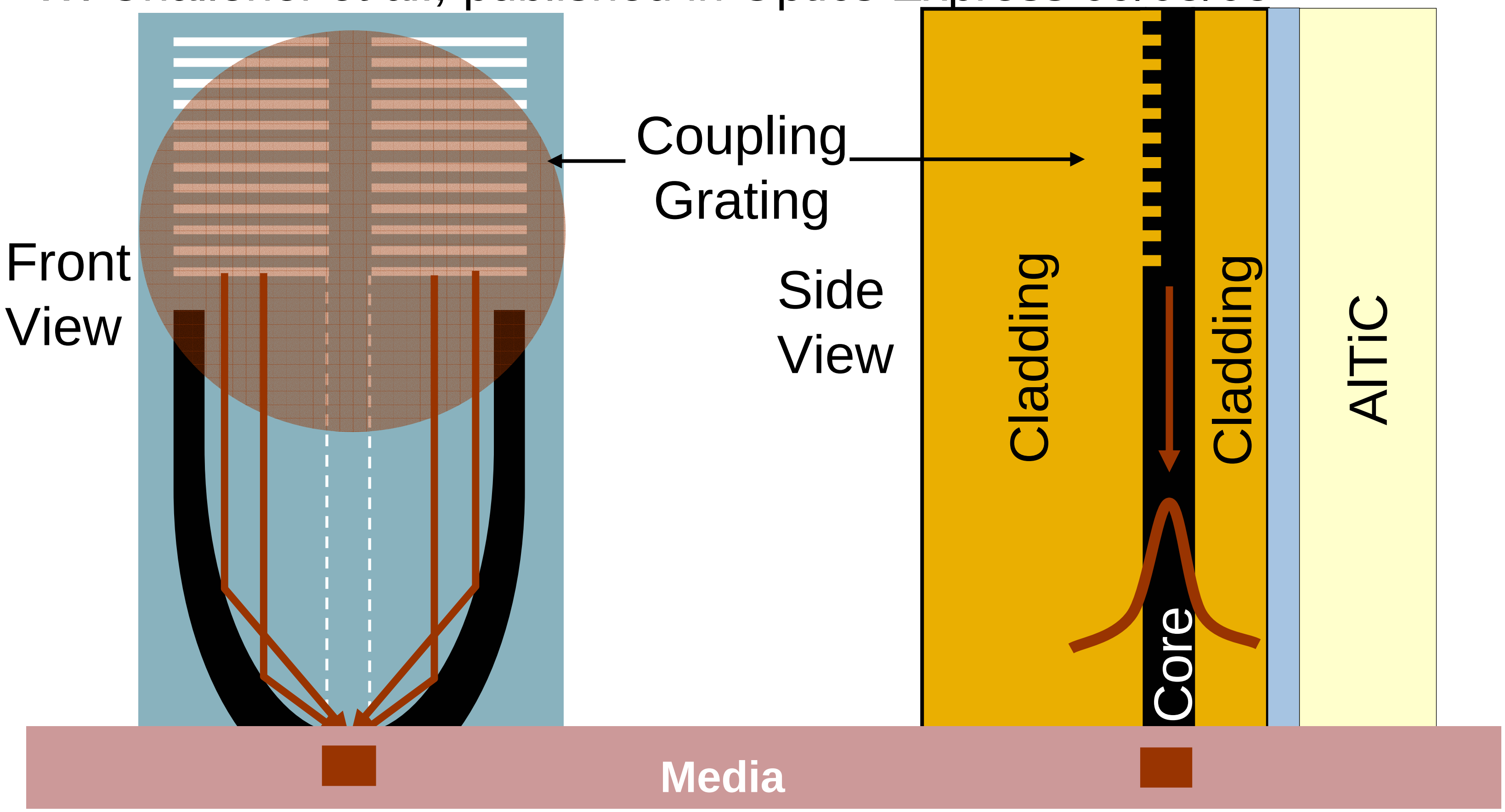
HAMR System



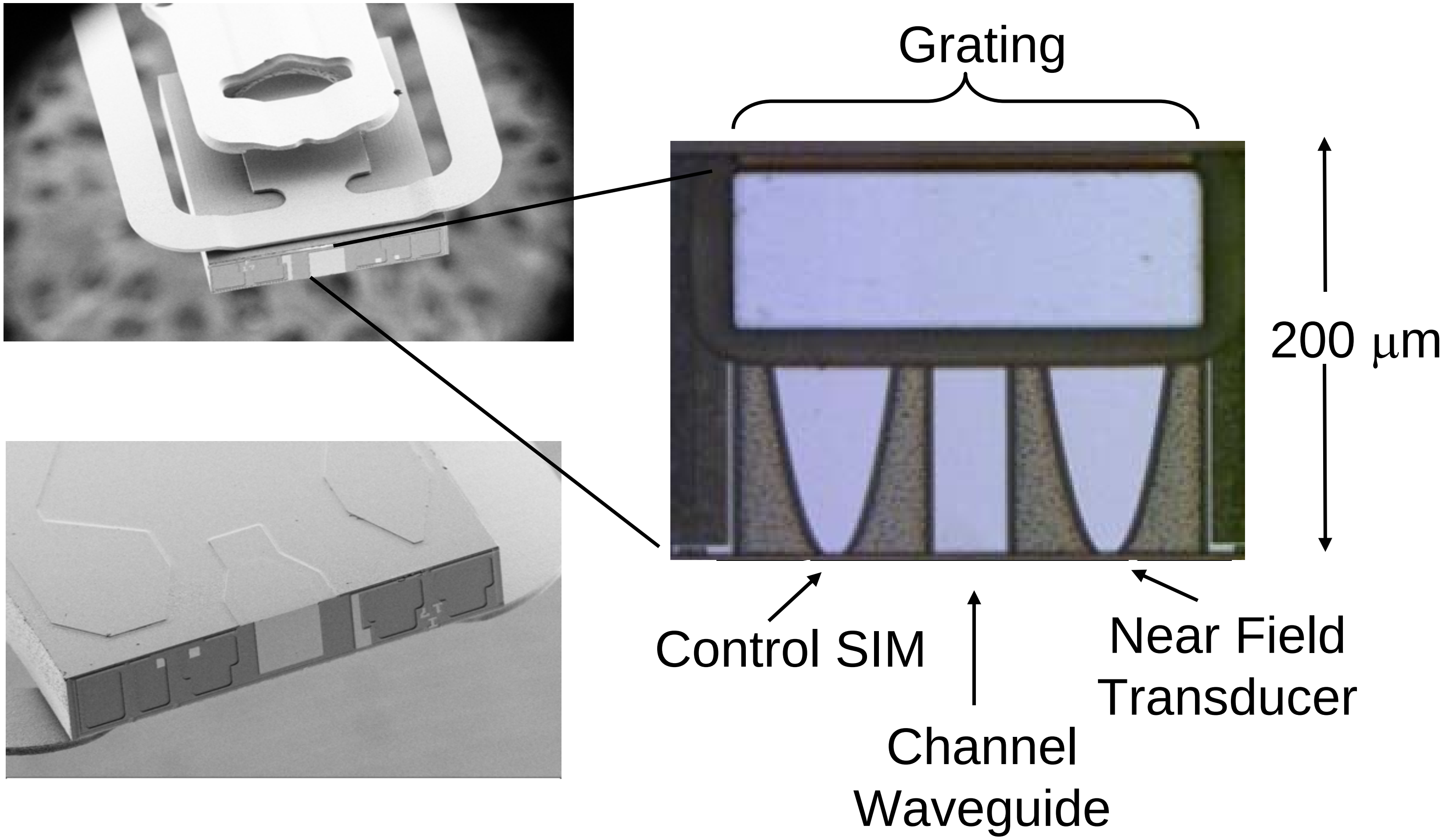
Suspension
Grating
Light Delivery
Laser Module on E-block
Return Pole
Waveguide
TGMR Element
Write
Coil
Write Pole
Lubricant/Overcoat
Magnetic
Media
Near Field Transducer
Heatsink/SUL

Recording Head - Optical Light Delivery
Planar **S**olid **I**mmersion **M**irror

W. Challener *et al.*, published in Optics Express 09/05/05



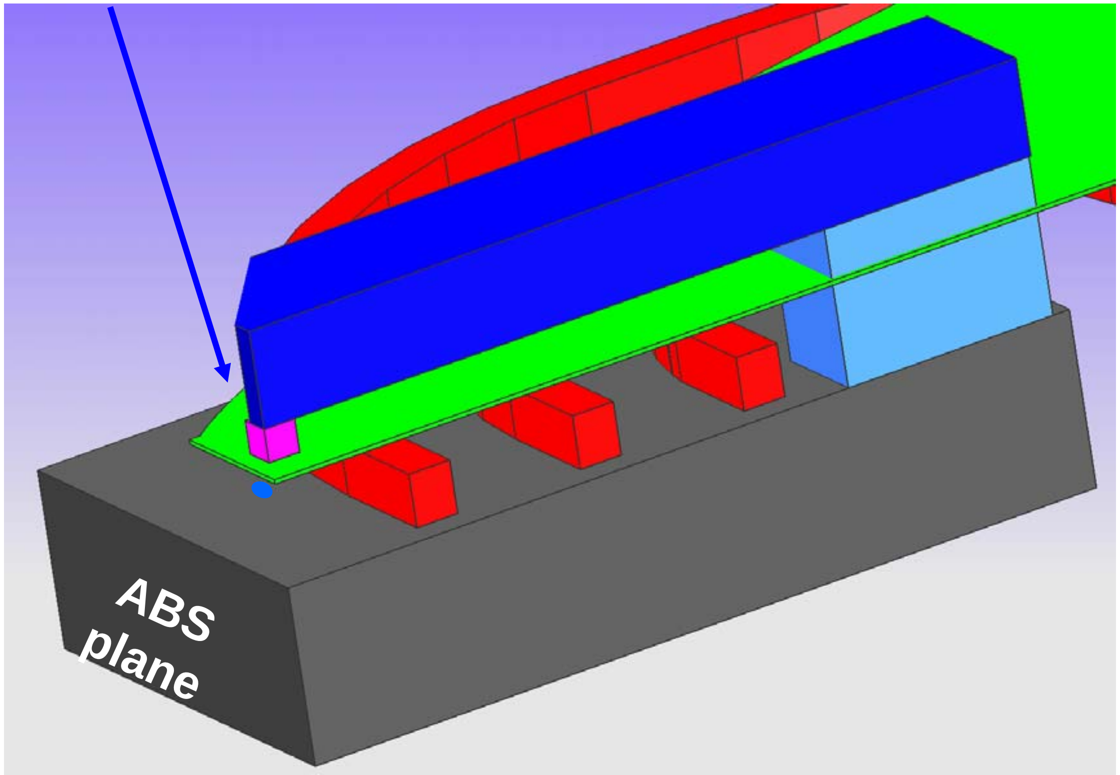
Completed Optical Heads



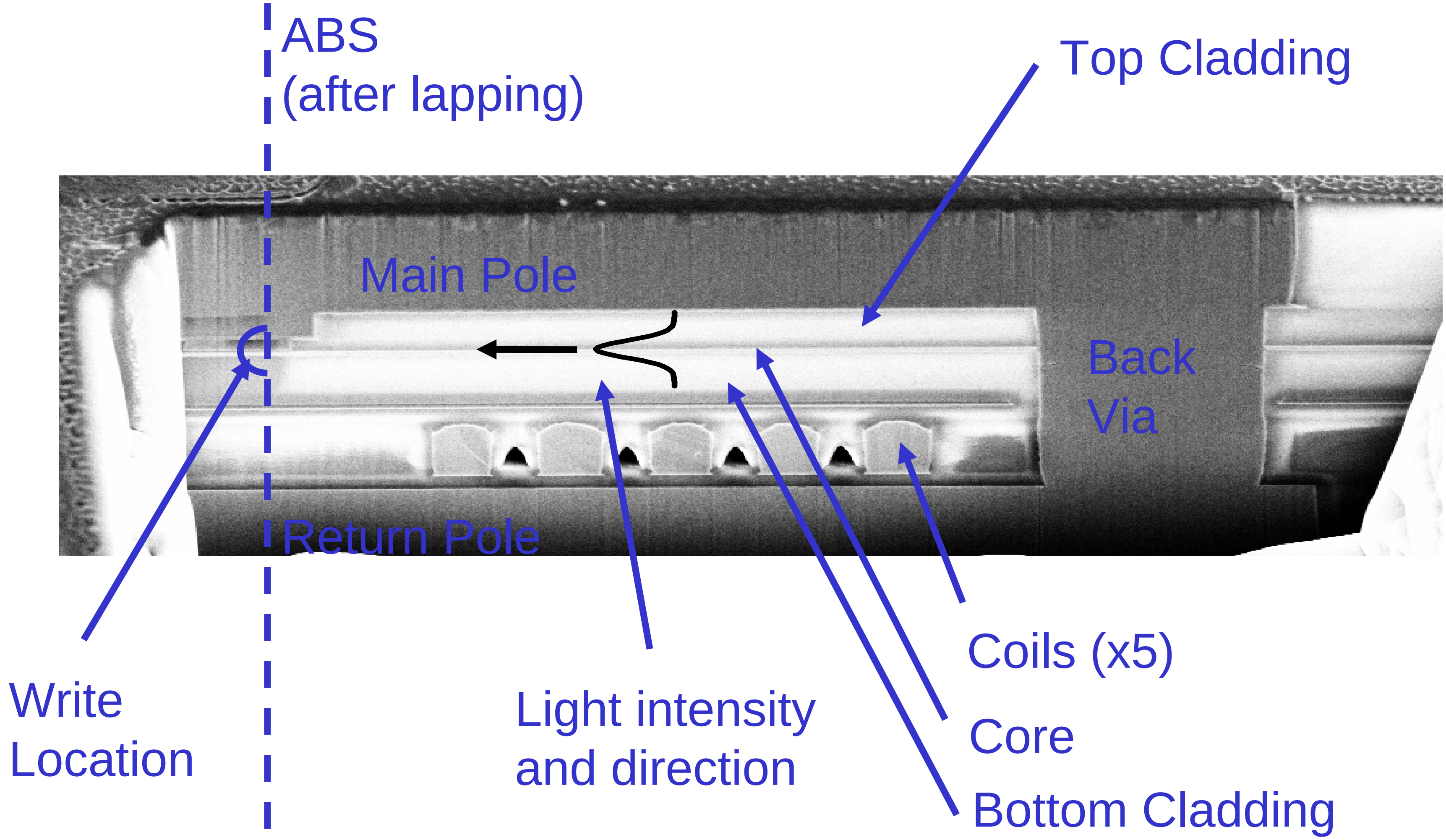
Optical & Magnetic Integration

PSIM in Gap of Asymmetric Ring Writer

Optical Waveguide/PSIM

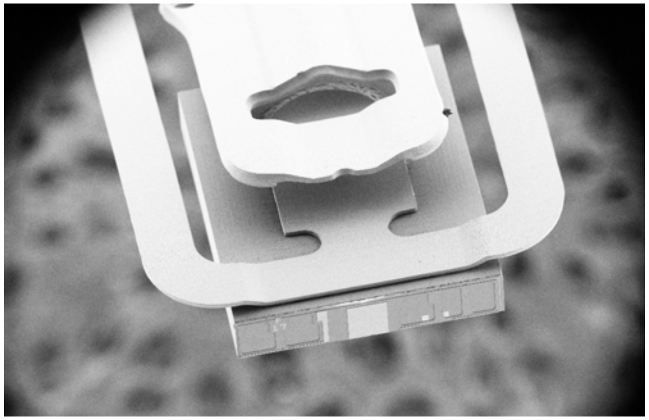


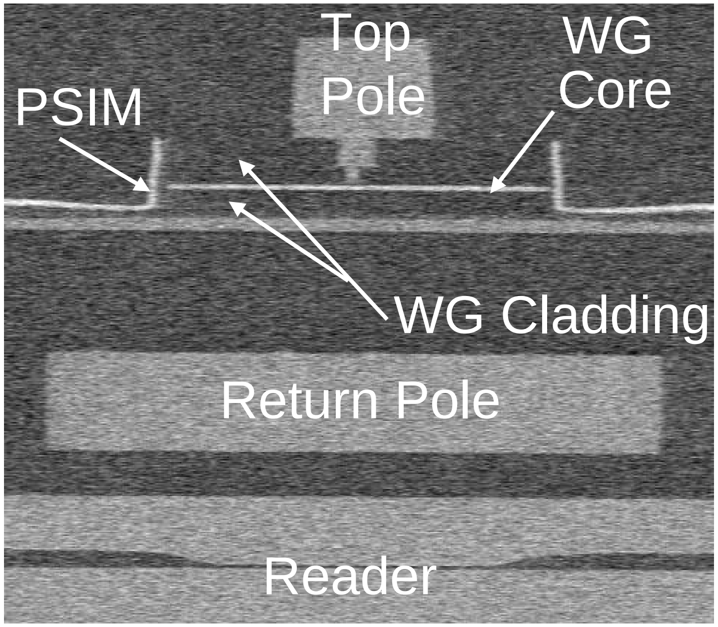
HAMR Head Cross-section

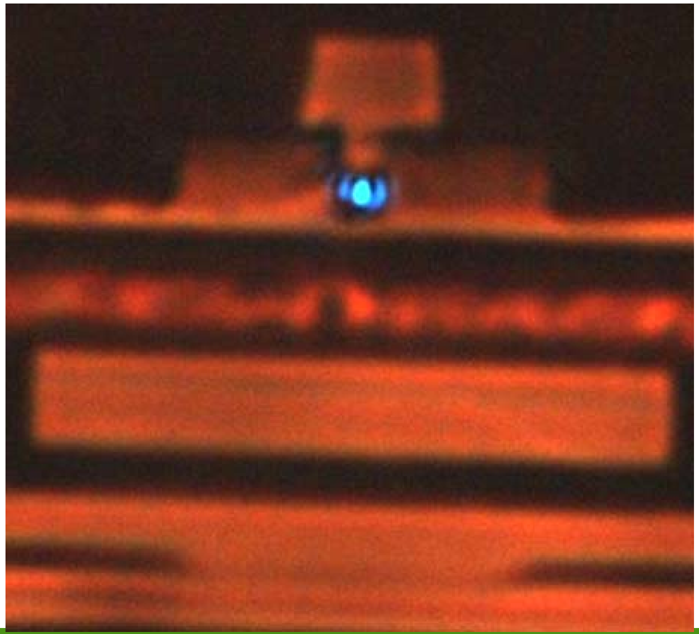


Wafer Level HAMR Head Fabrication

- Standard Thin-film processes used.
- 1000's of heads per 6" wafer.
- 1000's of heads built into sliders & HGAs.

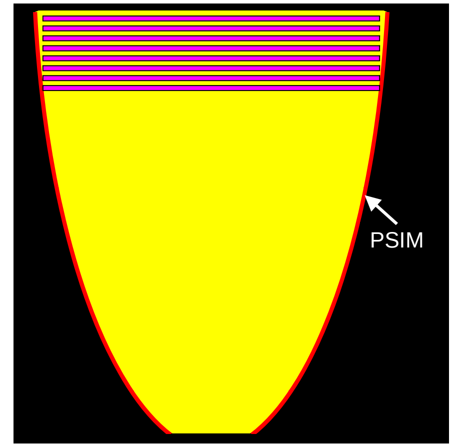


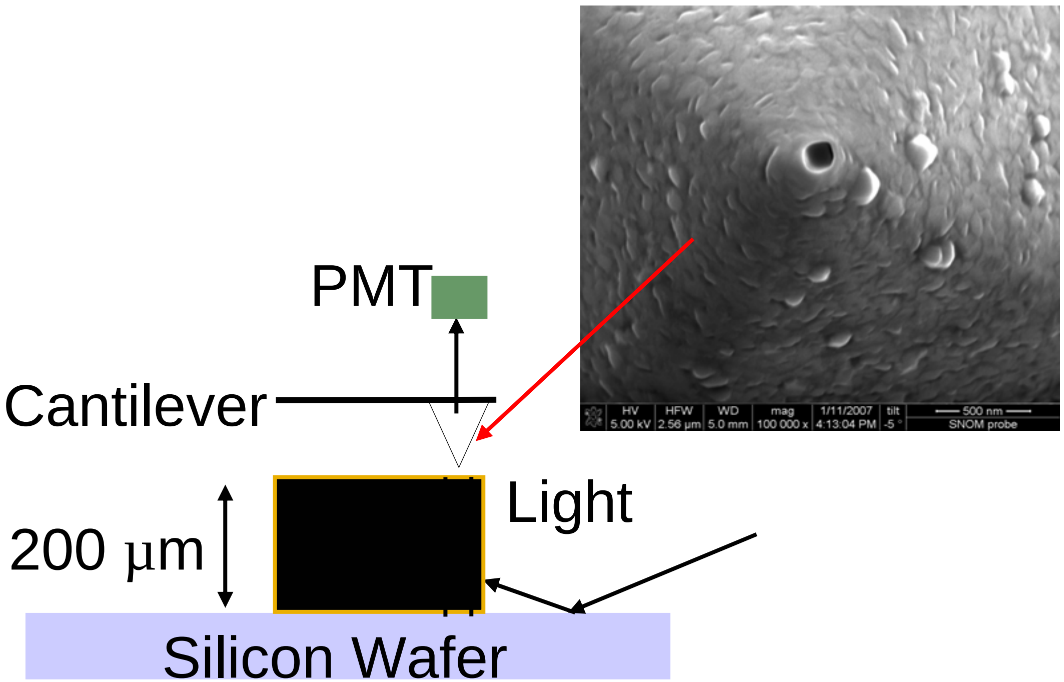


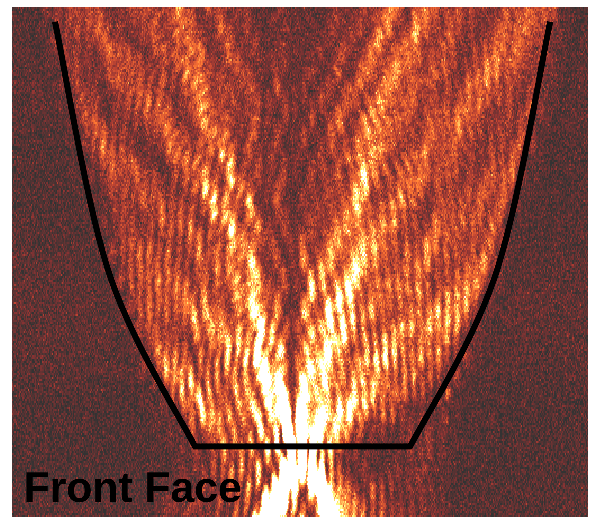


Characterization: *Witec* SNOM

- Scanning Near-field Optical Microscopy (SNOM) to evaluate PSIM focusing.
- A hollow, metal coated SiO_2 tip is scanned over sample surface in contact mode.

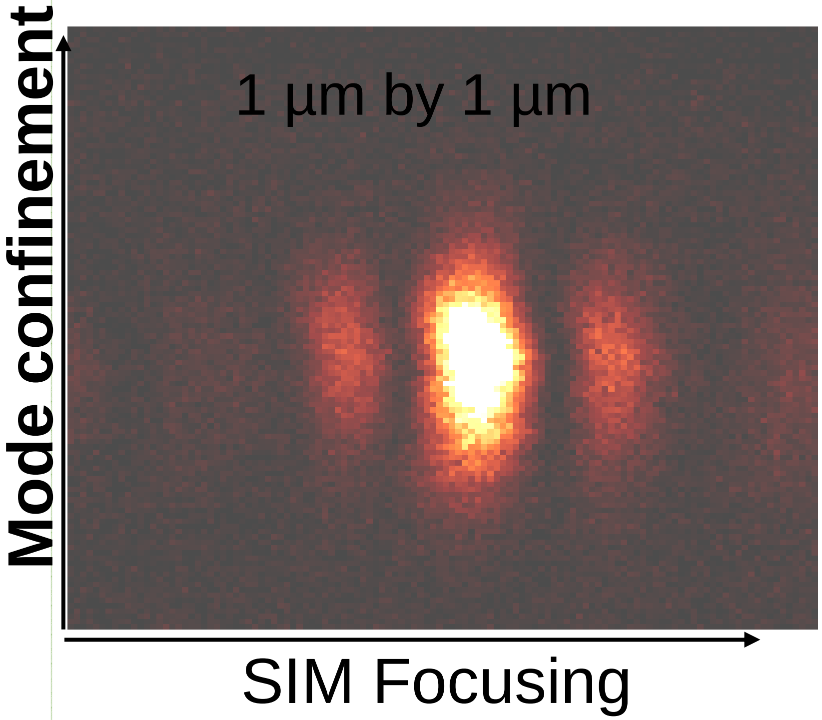


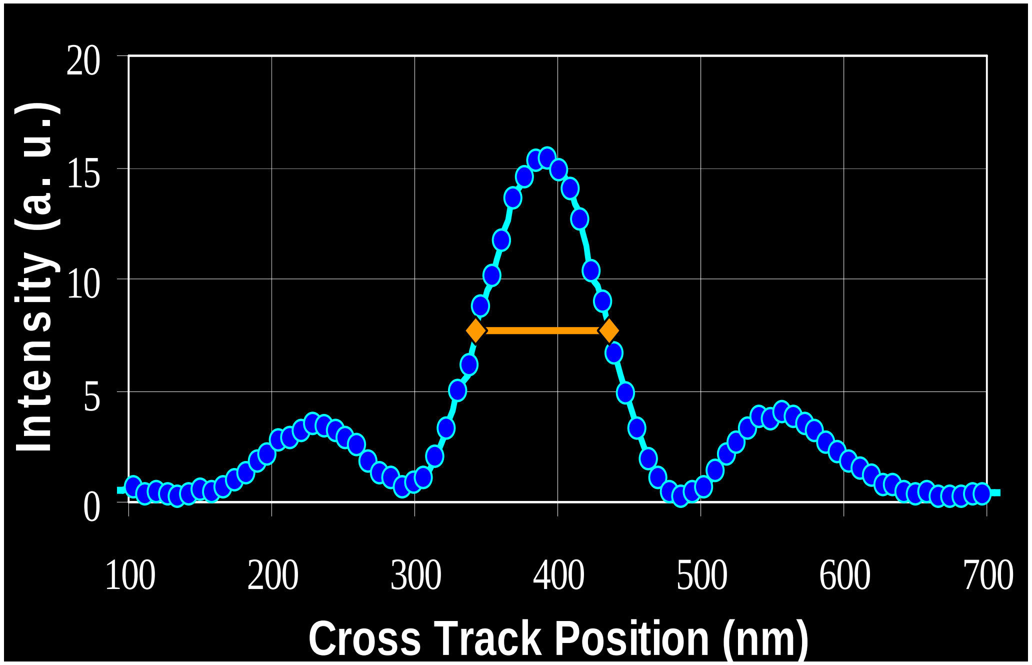




Near-field Intensity

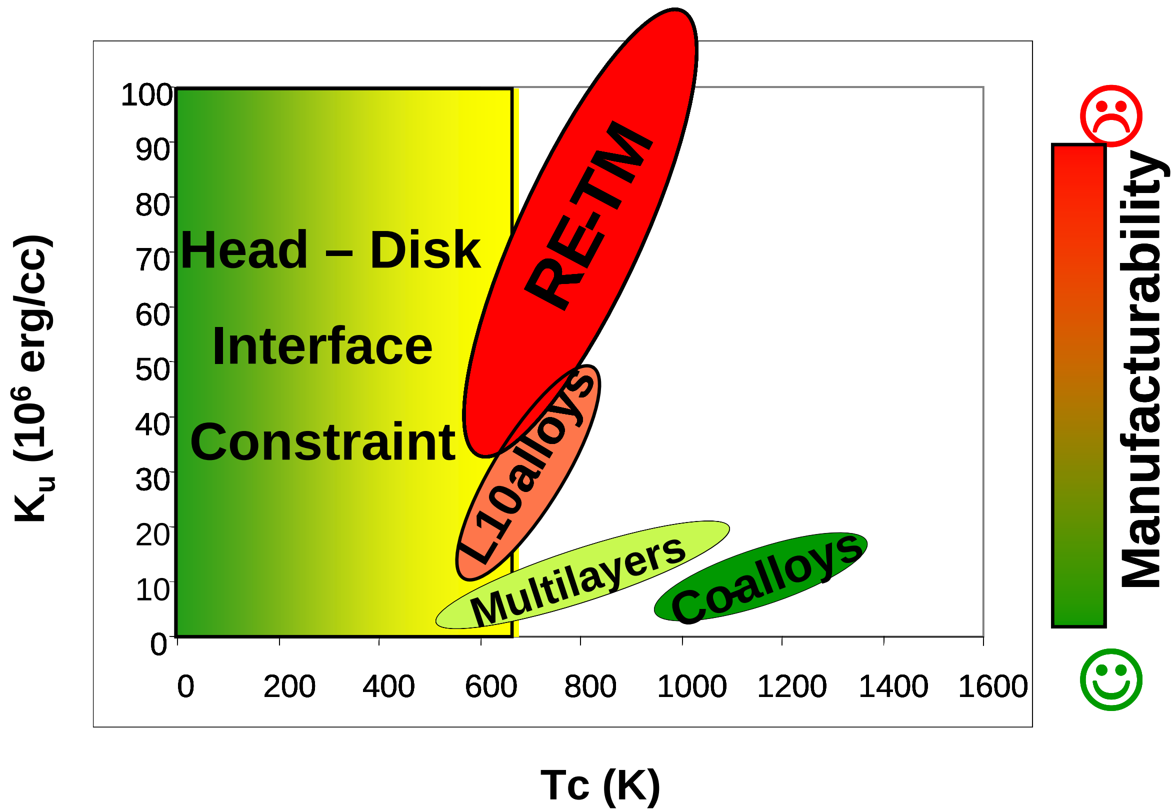
- SNOM scan over focal plane at ABS.
- At blue light (413 nm), FWHM focused spot size = 90 nm.





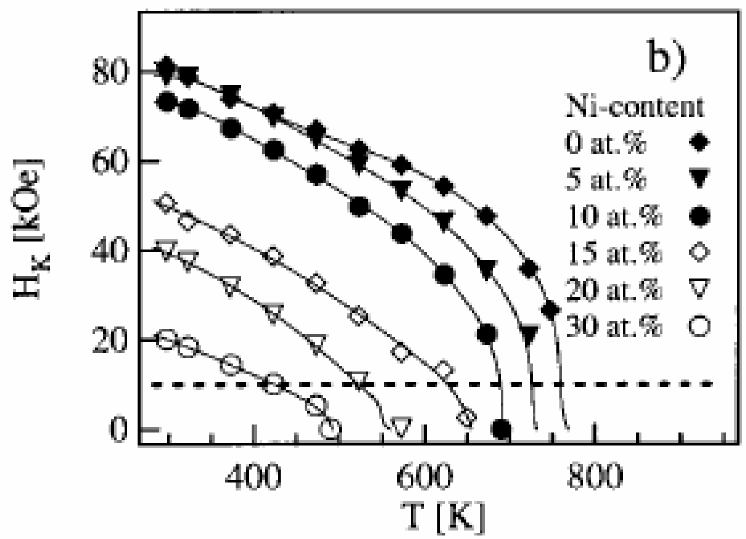
Recording Temperature Challenges

For areal density and low noise, we need high anisotropy
For reliability, we need low T_{write}



Anisotropy versus Curie Temperature

FeNiPt



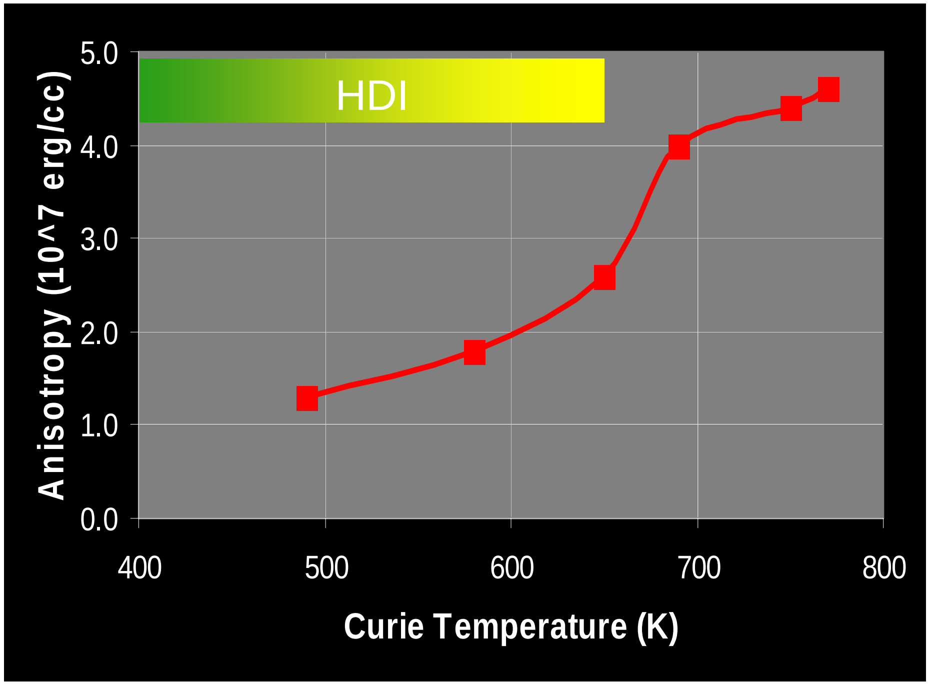
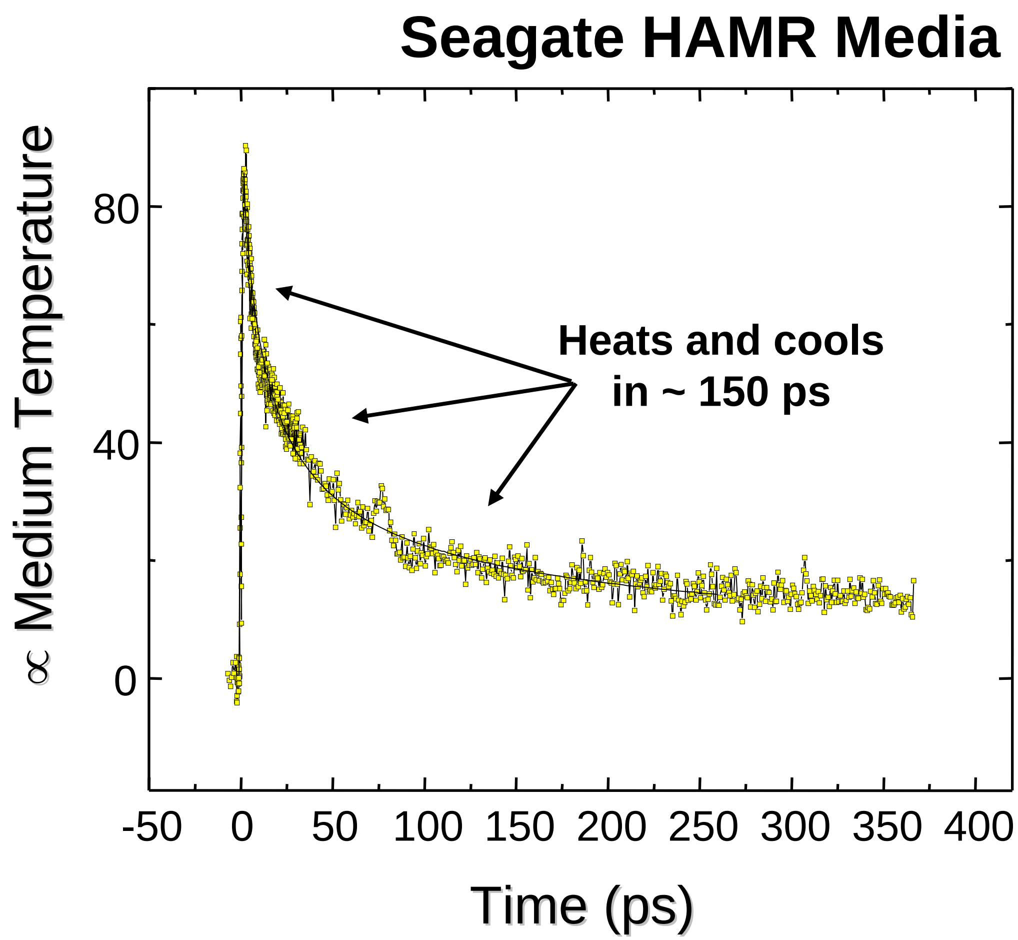


Figure and data from

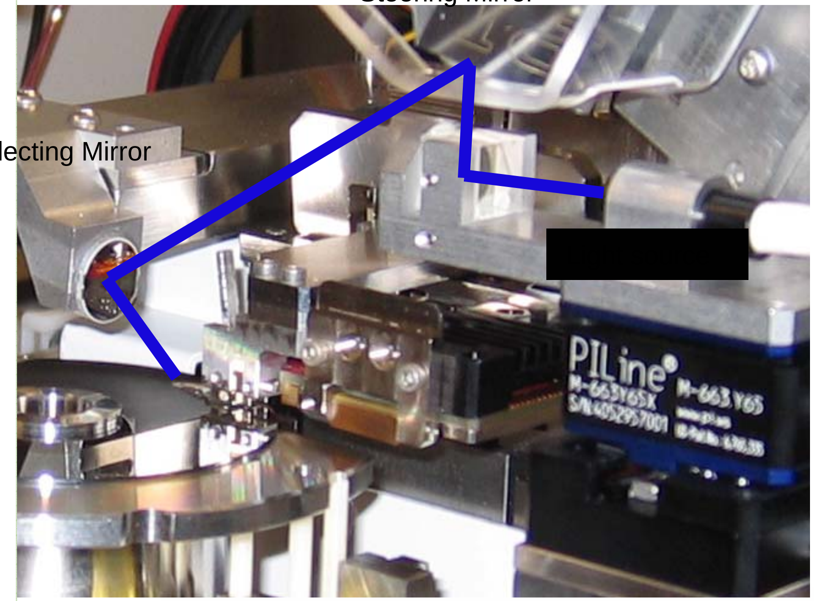
J. UThiele, K. R. Coffey, M. F. Toney, J. A. Hedstrom, and A. J. Kellock, " Temperature Dependent Magnetic Properties of Highly Chemically Ordered $Fe_{55-x}Ni_xPt_{45}L1_0$ Films," J. of Appl. Phys Vol. 91, pg 6595, 2002.

Fast Media Cooling

Media thermal response times are extremely fast when properly designed

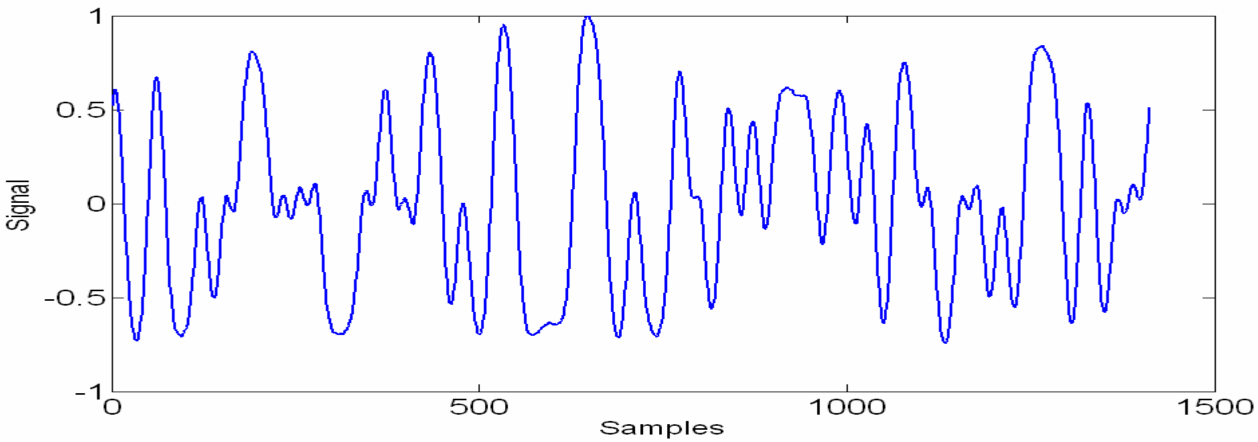


HAMR Spinstand Demonstration



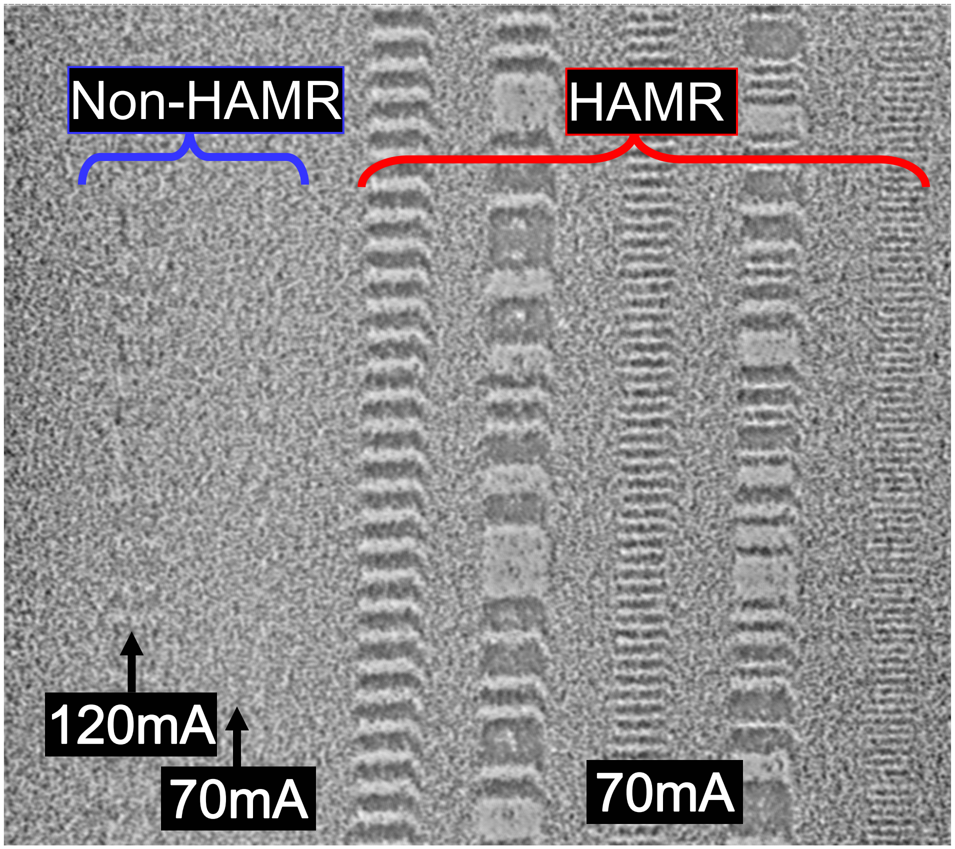
Spinstand recording performed with a fully integrated HAMR head and HAMR medium

Time domain PRBS data



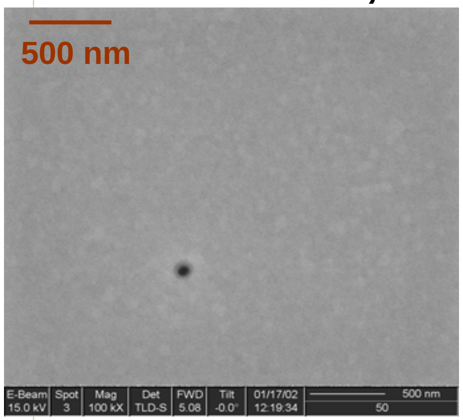
MFM of Non-HAMR & HAMR Tracks (Fully Integrated HAMR Head)

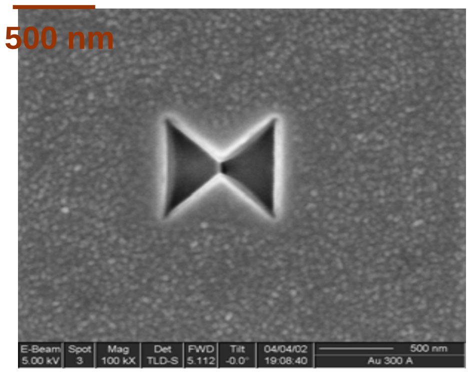
- Fully Integrated HAMR Head
- HAMR Unique Media
  - High Anisotropy
  - Proper Heatsinking

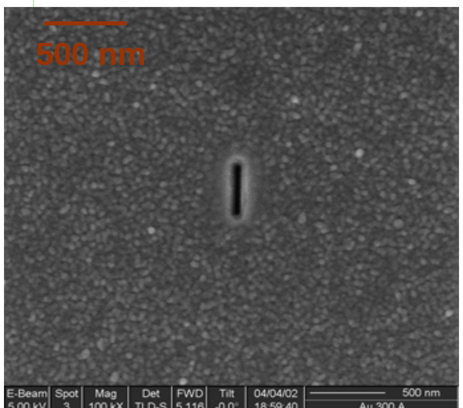


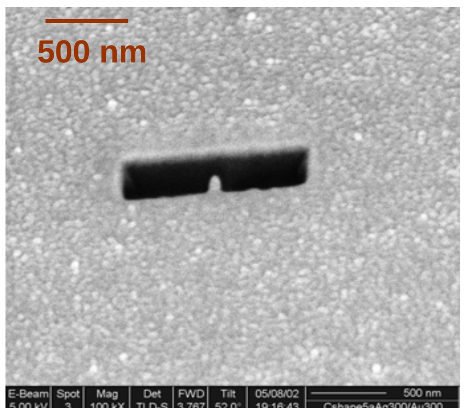
Near Field Transducers

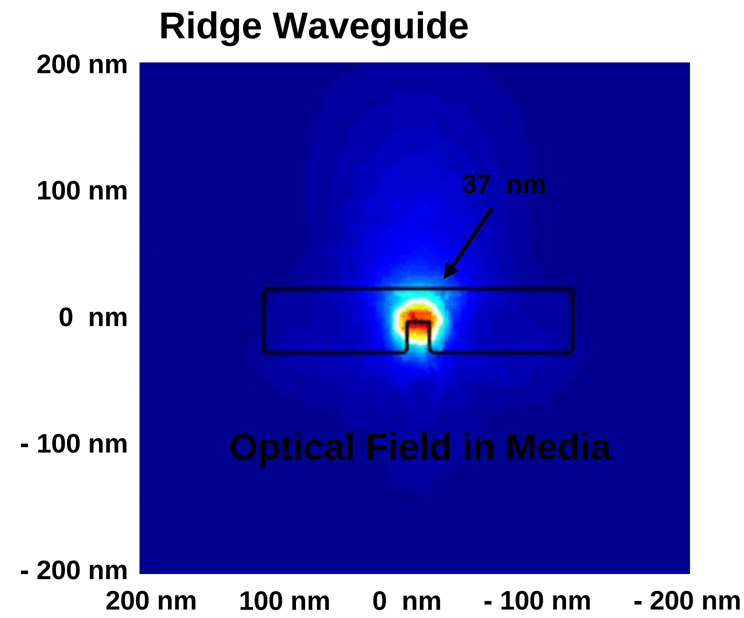
- **NFT to reduce the optical spot size.**
  - **Aperture, bowtie, ridge WG, beaked antenna, …**











– Nano-Holes
  - L.Yin et al., APL 85 (3), pp. 467–469 (2004).
  - E. Popov, et al., *Appl. Opt*. 44, pp. 2332-2337 (2005).

– Rectangular Aperture
  - Shi, et al, Jap. J. Appl. Phys. 41 (2002).

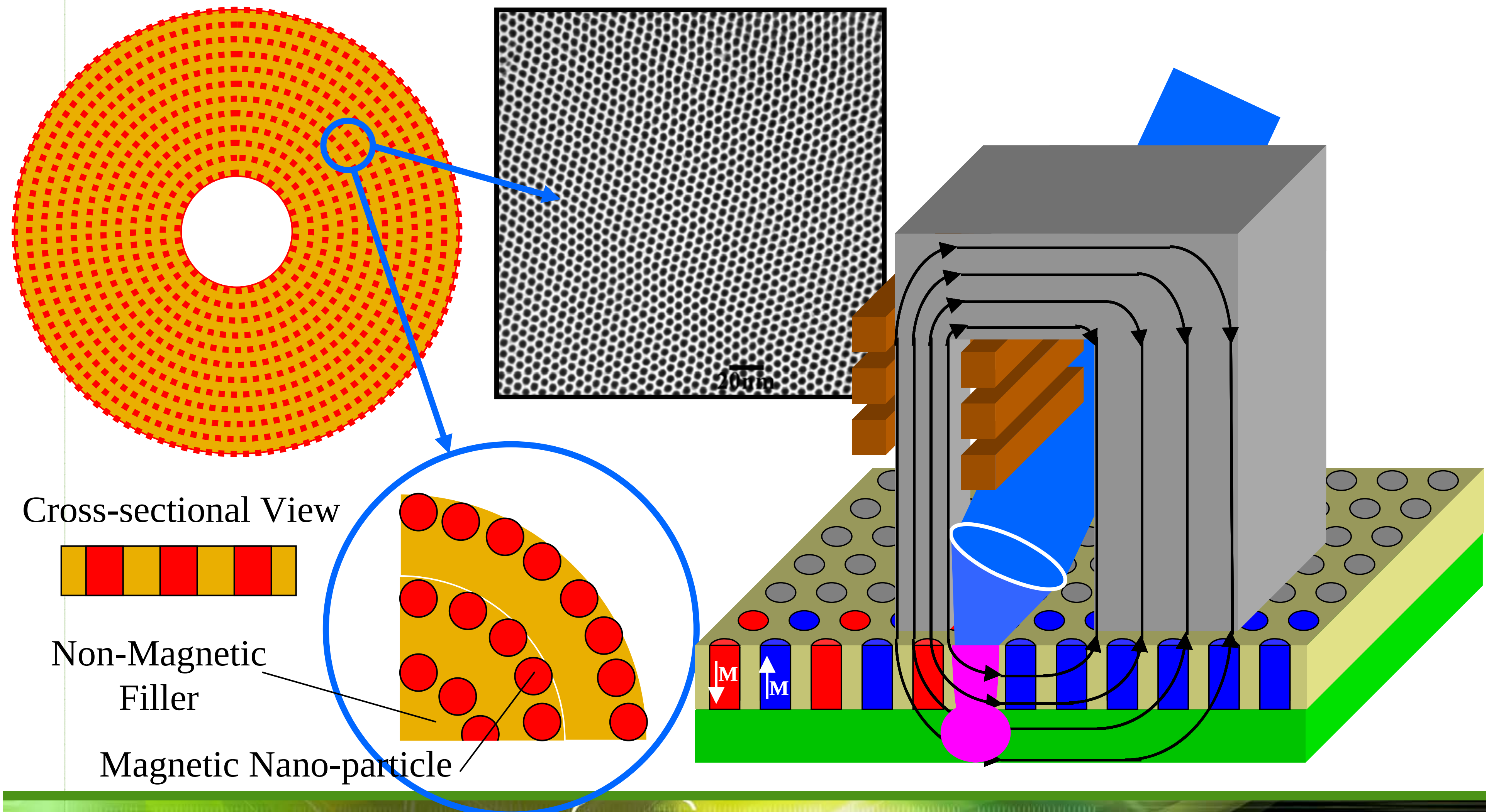
– Bowtie
  - R. Grober, et al, APL 70, pp. 2368–2370 (1997).

– Hitachi - Beaked Antenna
  - T. Matsumoto, et al, ISOM/ODS'05, (2005).

– Sharp - Smash Head
  - S. Miyanishi INTERMAG (2005).

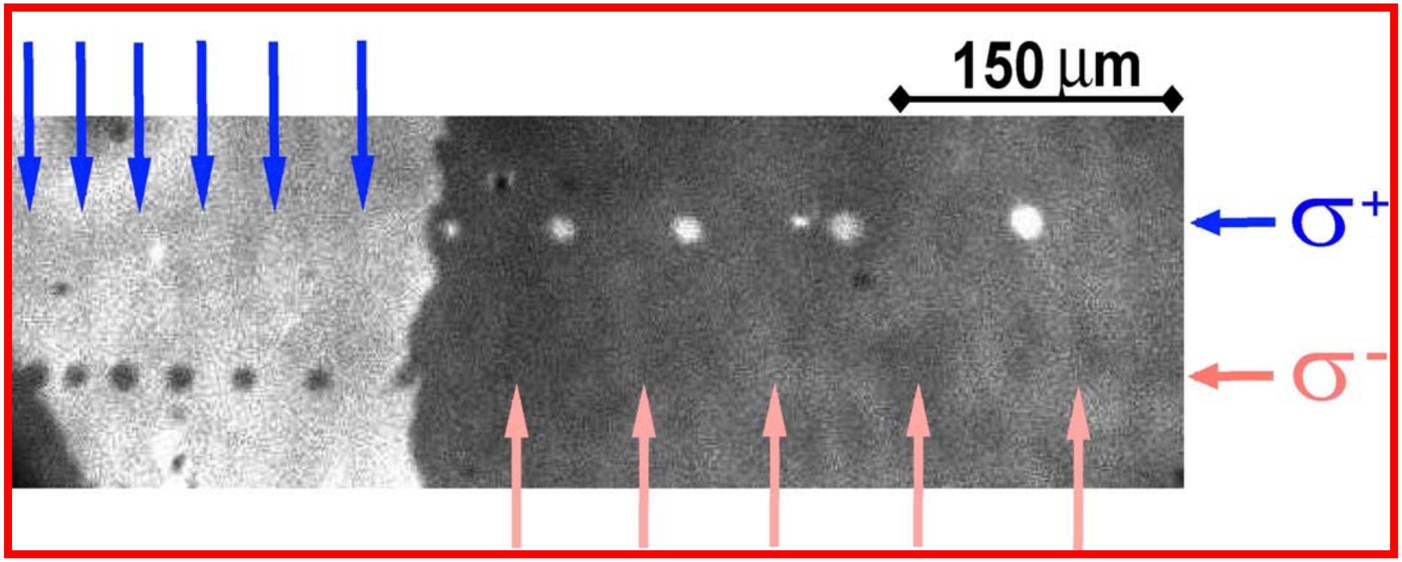
– Sony - SIL + Single Pole Head
  - N. Kojima, et al, INTERMAG (2007).

HAMR + Bit Patterned Media

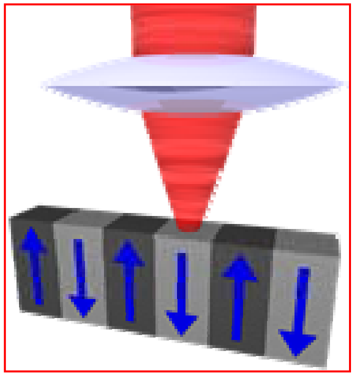


Optical Switching with a Single Pulse

Sweeping the pulsed laser beam at high speed across the sample



GdFeCo



- Each domain is written with a <u>single</u> 40 fs laser pulse
- **THz optical magnetic recording is possible!**

Rasing Group, Nijmegen October 2006

Summary / Conclusions

- HAMR is a candidate alternative technology to allow further HDD AD scaling.
  - Conventional perpendicular recording may be limited to a 1 Tbpsi.
  - HAMR allows high anisotropy materials to be recorded.

- The fully integrated HAMR heads were built & tested.
  - Design uses conventional head processing technologies.
  - MFM image shows HAMR is required for high Hk HAMR unique media.
  - *Demonstrated HAMR writing with fully integrated HAMR heads & HAMR media.*
  - Combining HAMR & BPM may further extend areal density.