A Concept to Enable High Quality Imaging With 10x Chandra Area

Presented by Melville P. Ulmer
Department of Physics and Astronomy and the Center for Interdisciplinary Exploration and Research in Astrophysics
Northwestern University
E-mail m-ulmer2@northwstern.edu
http://faculty.wcas.northwestern.edu/ulmer
Phone (01)-847-491-5633

Additional authors: X. Wang, M. E. Graham, S. Vaynman, J. Cao (NU)

Overall, we'd like 10x the area of Chandra (at least) with Chandra angular resolution at an affordable price. The technology I present is one potential path to achieving the results by using thin walled shells (Ni, e.g. XMM or glass, e.g. one IXO option)

Concept: films of alloys (called magnetically smart materials or MSMs) respond 400 - 1000x or more strongly to an inserted mag field than Fe, Ni, or Co alone.

Terfynol-D was developed by the Navy in the 1960s for sonar. Lots of studies have been done, but have never taken off commercially. A company has survived, however.

Our concept. Mandrel is “perfect”. Remove mirror.

Stress therein distort the shape, but there is a 1-1 map back to the “perfect” master.

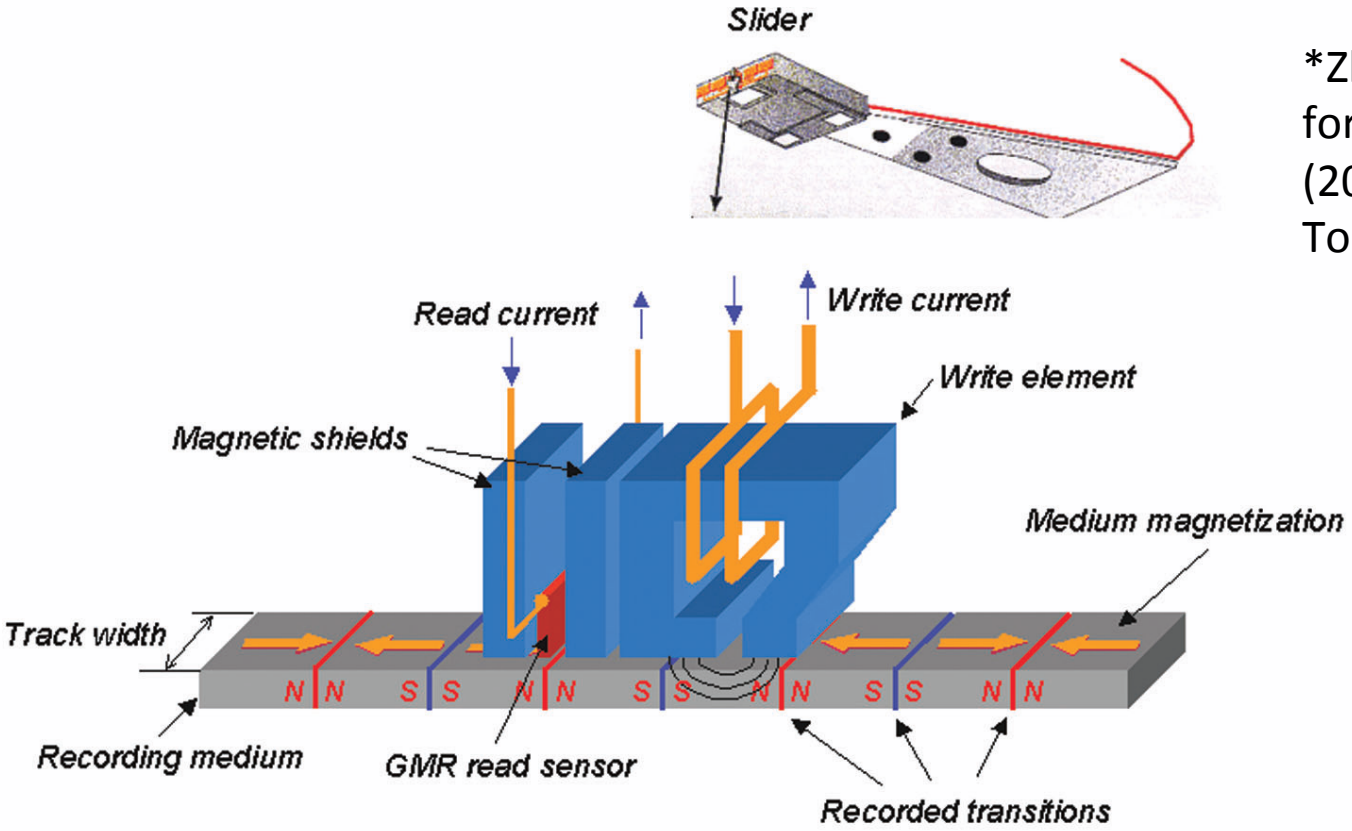
⇒Measure mechanically the mirror. Use FEA/FEM to tell where stresses are.

⇒Coat with MSM, (probably add stresses but some could cancel original ones)

⇒Apply magnetic field based on MSM knowledge and FEM/FEA work. Apply metrology Iterate until it works.

⇒Then take to beam line or MSFC for final proof

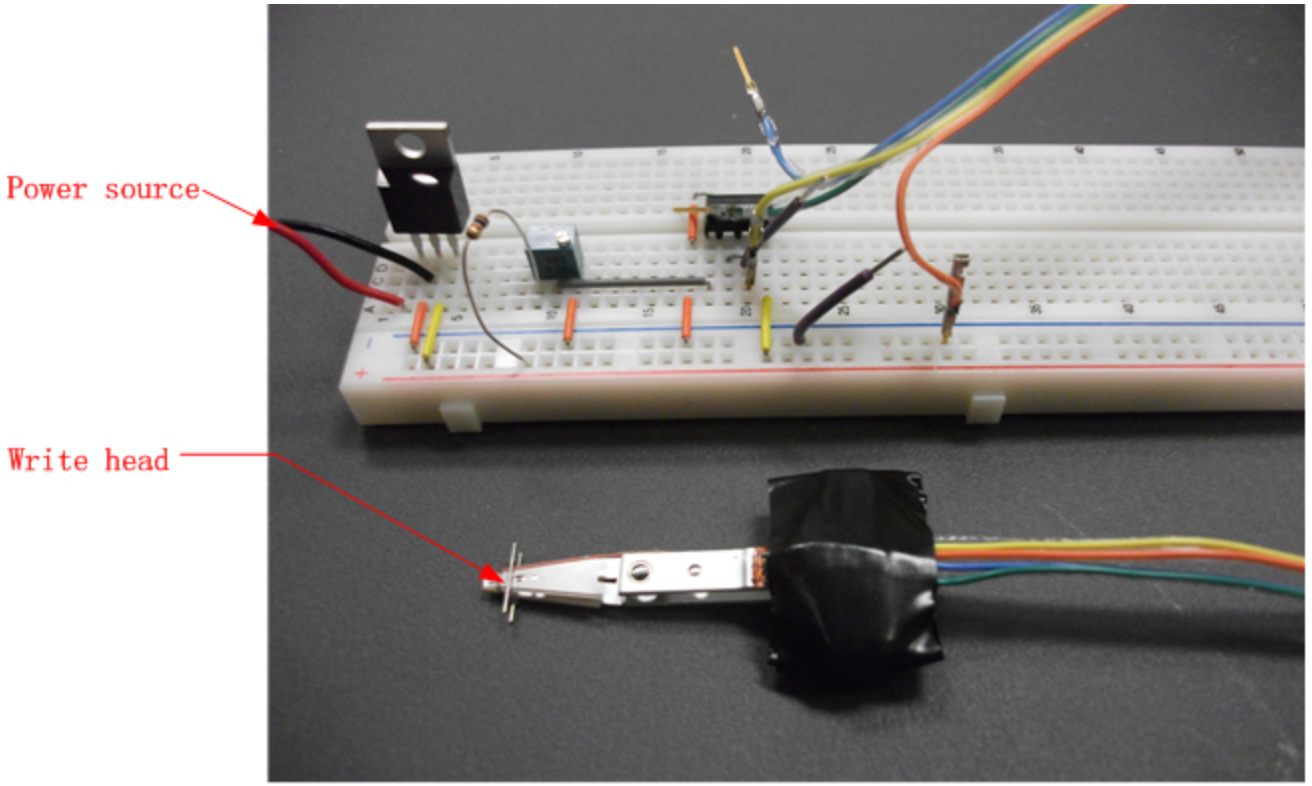
Electric magnetic write head



*Zhu J, New heights for hard disk drives (2003), Materials Today, p22-30

The head material in the gap region has changed from permalloy ($Ni_{81}Fe_{19}$) with saturation flux density B_s=1.0 T to $Ni_{45}Fe_{55}$ (B_s=1.5 T)to $Fe_{65}Co_{35}$ (B_s=2.45 T). The maximum write field inside recording media in longitudinal mode is limited to 1.2 T.

Preliminary test set up



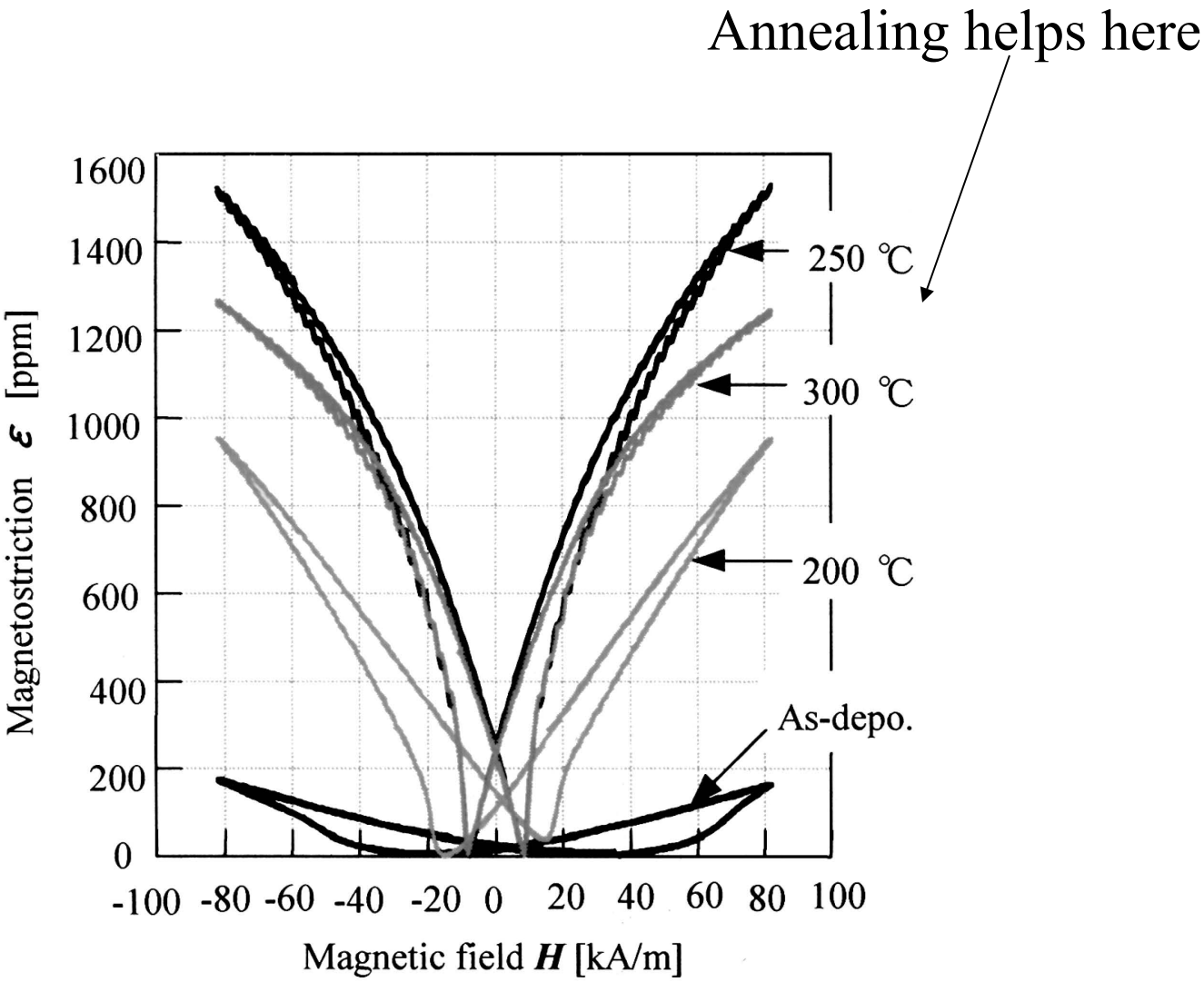


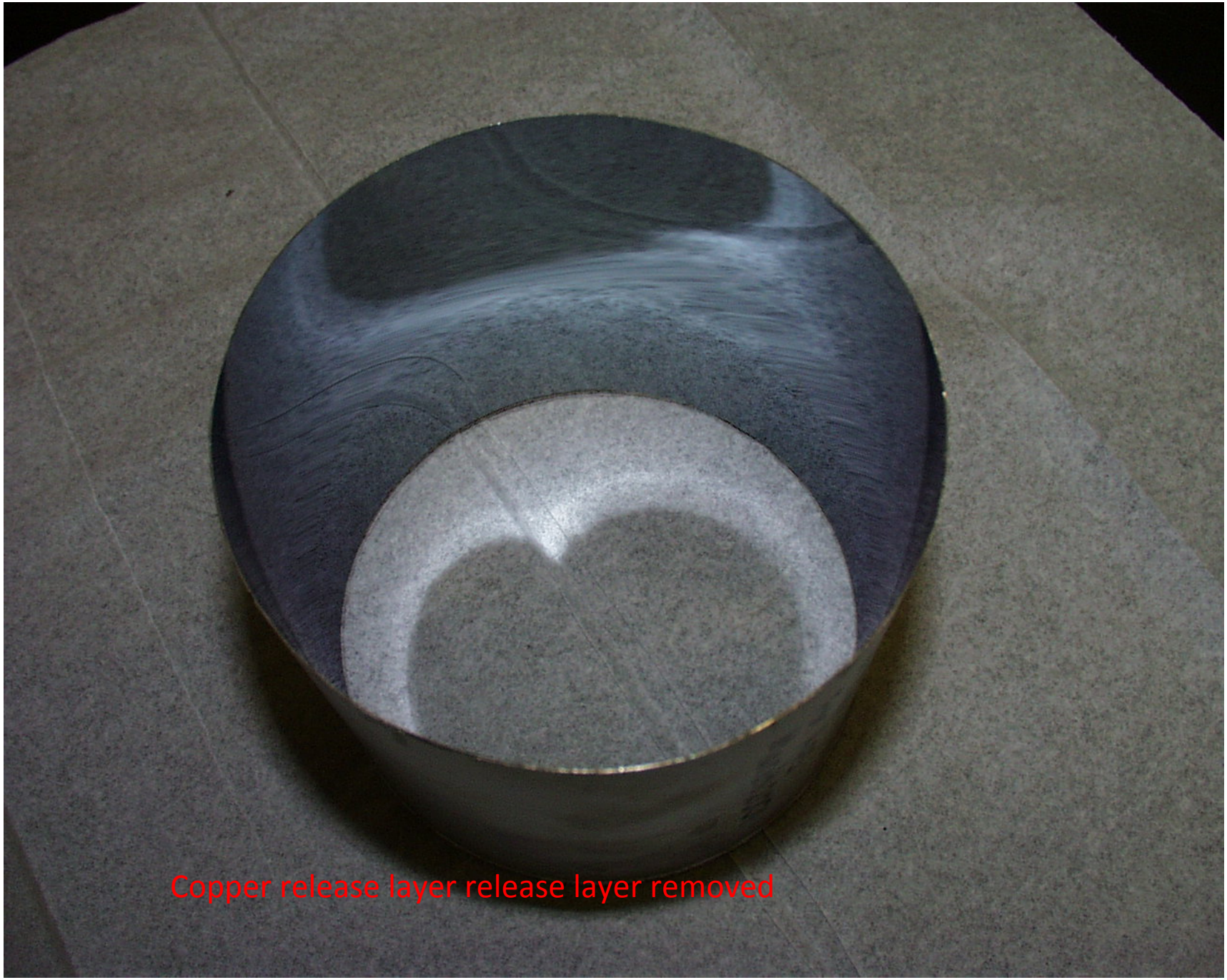
Fig. 7. Magnetostrictive properties of thin films with Co ratio 80.1%.

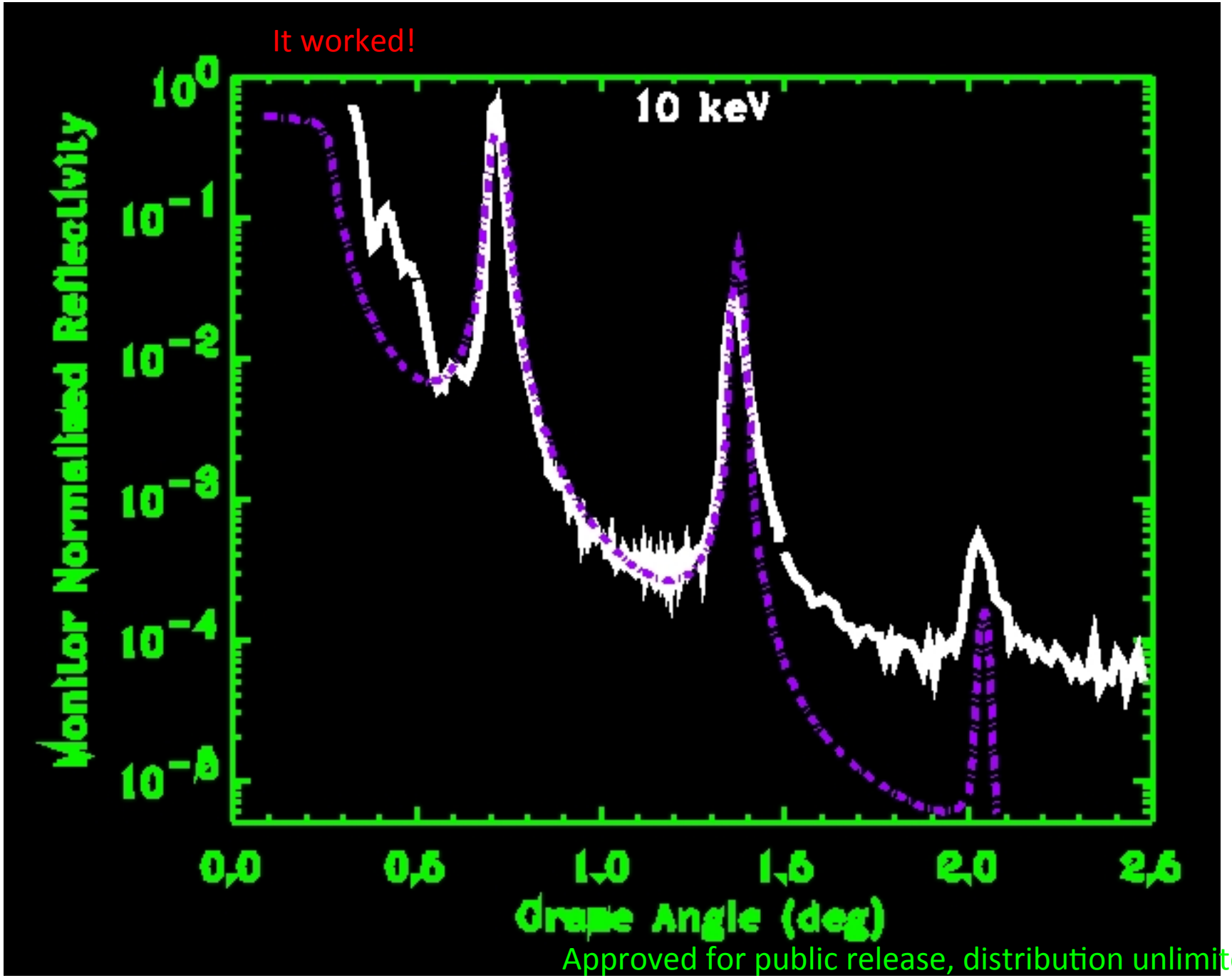
100 kA/m ≈1.23kG

If use magnetically hard substrate = Co-Ni, can write in magnetic field and “set it and forget it” if the vibration loads are not too much.

For materials that doesn’t hold a magnetic field can put down a Ni-Co coating first or keep power on the magnetic field.

Wolter I multi-layers anyone for the HE part to IXO?

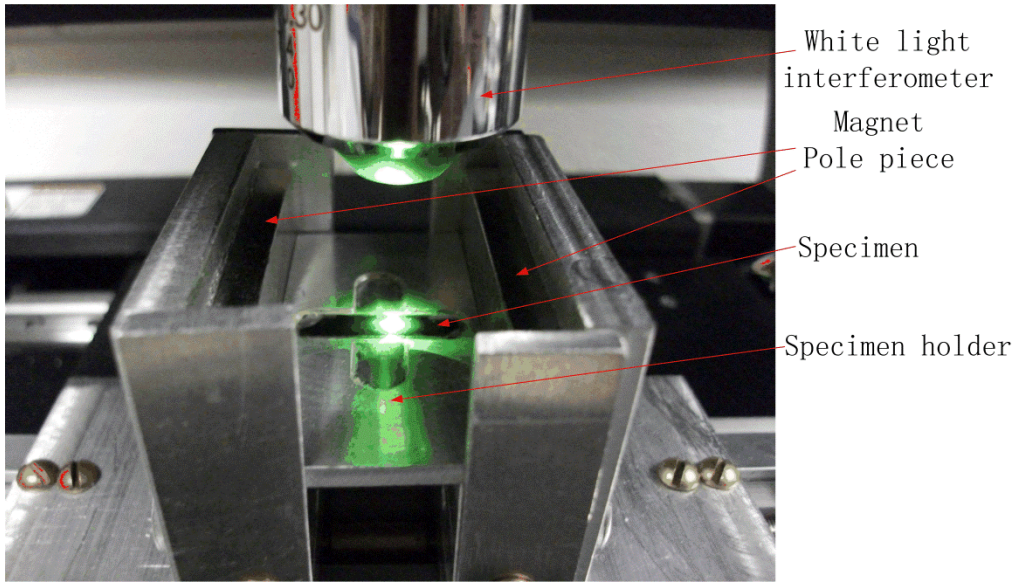

Copper release layer release layer removed

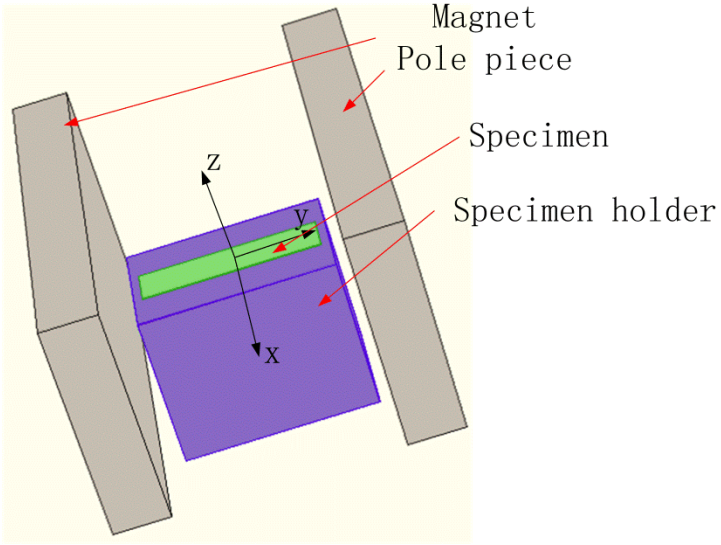


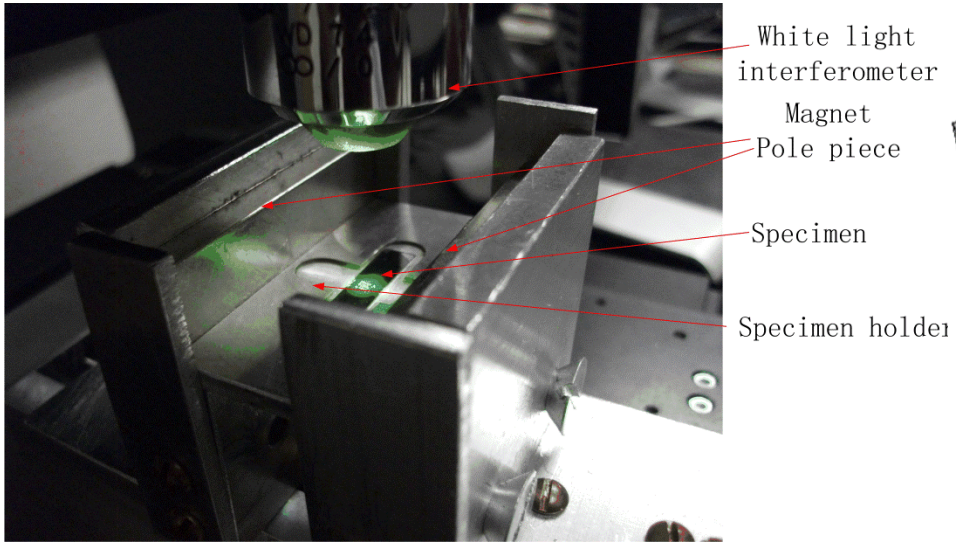
Basic measurements: NewView 7300 White Light Interferometer

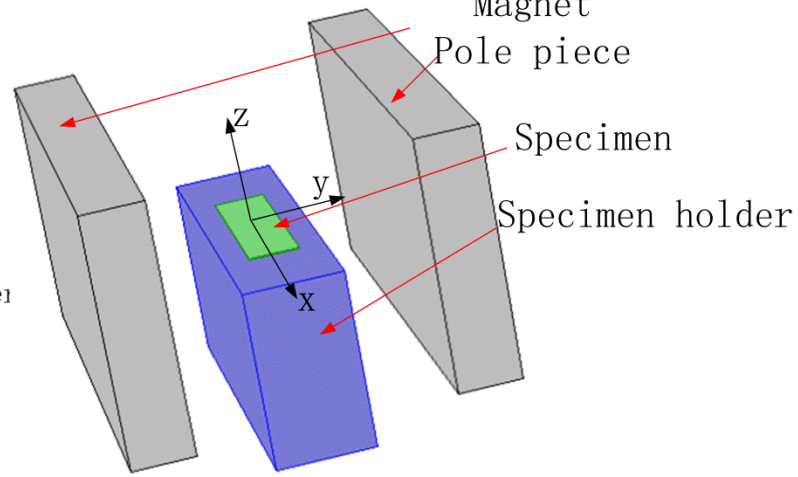
- Non-destructive 3D surface metrology tool
- Surface height measurement : from 1 nm to 20 mm
- Sub-nanometer resolution
- < 0.01 nm RMS repeatability
- Fully automated and programmable xyz stages
- ≤ 135 μm/sec scan speed
- 10x and 50x objectives

Experiment Setup todate

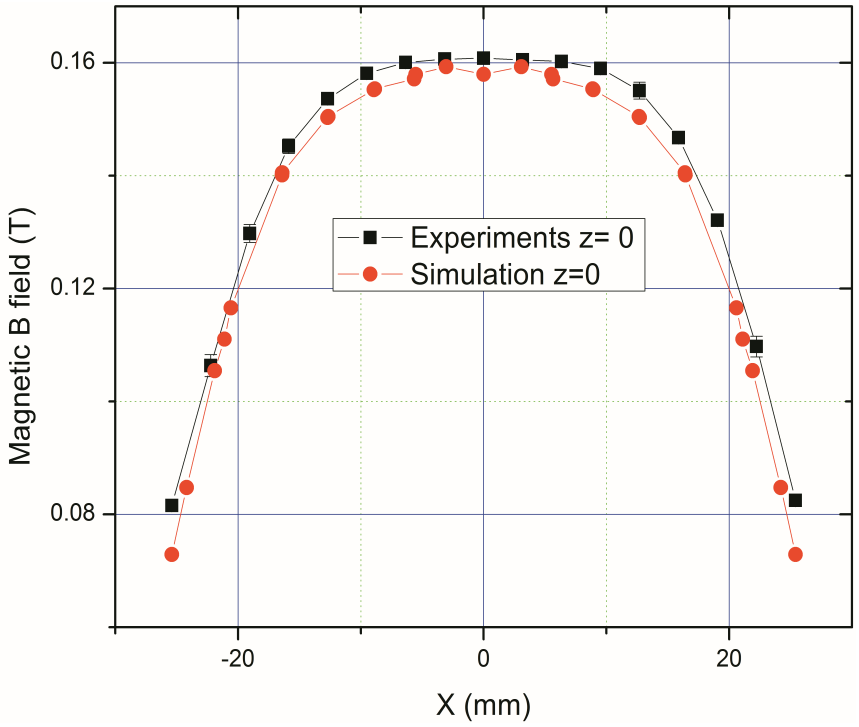




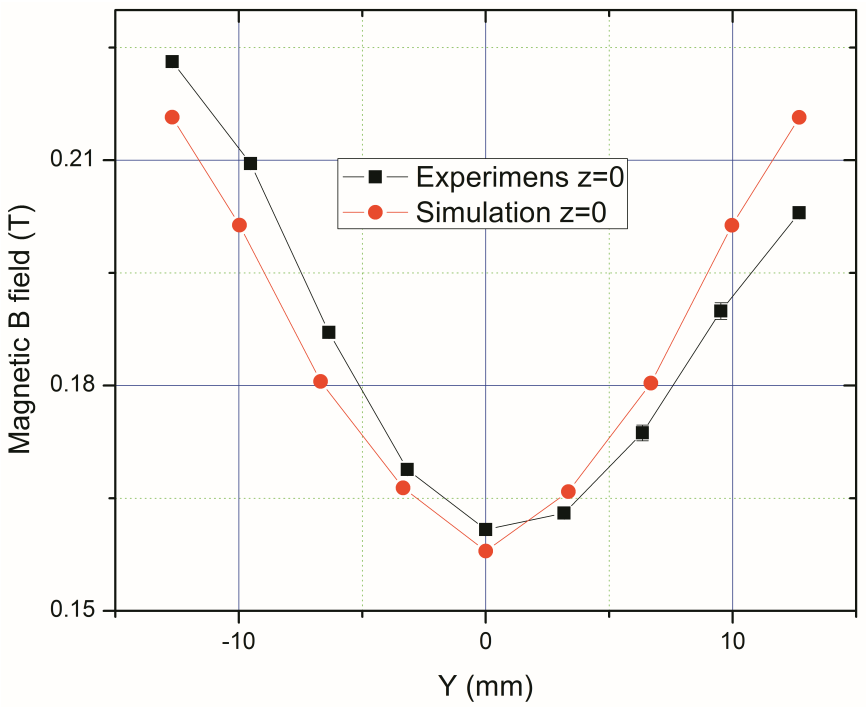




Magnetic field between the two magnets in our test set up



Uniform along the long direction of the specimen



Not uniform along the long direction of the specimen

The length of the specimen: 20 mm

Path to technical maturity.

Perfect technique on flats including

(1) Determine optimal film thickness

(2) Determine optimal annealing temperature

(3) Determine optimal substrate thickness and material, e.g glass coated the Co-Ni, Co-Ni

(4) Determine how to control figure first on flats and then on cylinders, then on Wolter I or full scale IXO-type design

Summary and Conclusions

The MSM concept hold great promise.

Can be applied to:
Wolter I (with or without multi-layers)

Slumped glass to remove mid-frequency ripple in particular, with/ without multilayers

Bragg Crystals or maybe even K-B mirrors for NGLS synchrotrons

Here's Hoping!!