GB01

An investigation of noise increased in TMR readers during drive operation

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Outlines

(1) Reader changes in drive reliability tests

(2) Recoverable or Non-recoverable by re-aligning HM

(3) Noise non-recoverable by re-aligning HM, and the causes

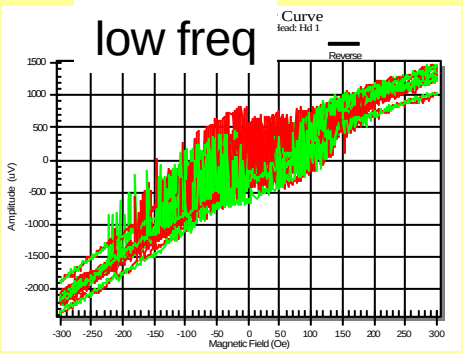
(4) Conclusions

(1) Reader changes in drive reliability tests

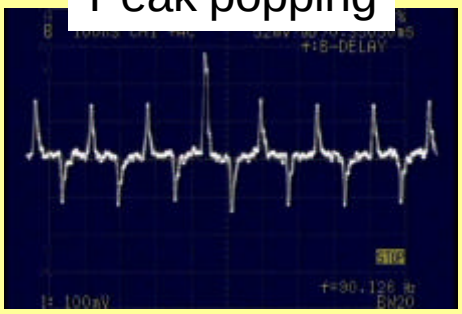
- TMR reader failure in drive reliability tests <100dppm by head, averaged over programs, composed of,

Noise increased

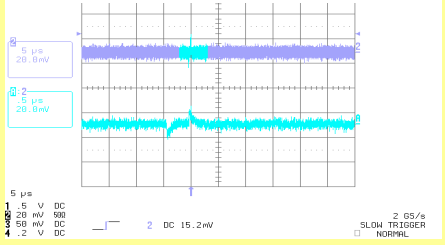
low freq



Peak popping

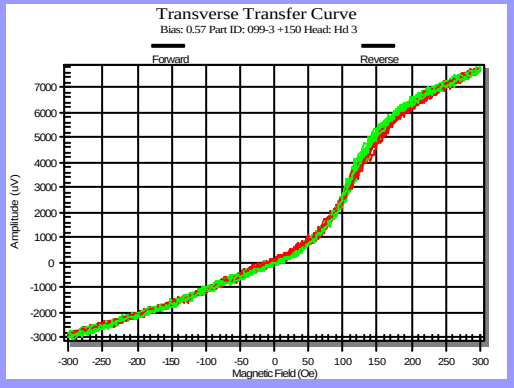


baseline popping



Noisy baseline

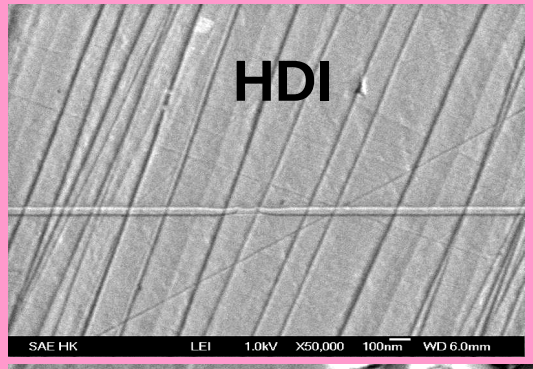
Transfer curve changed
as change in asym &/or amp

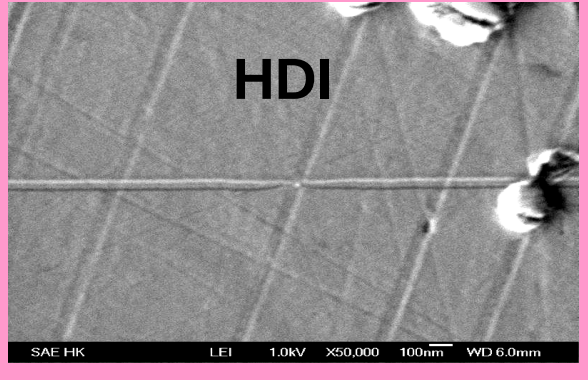


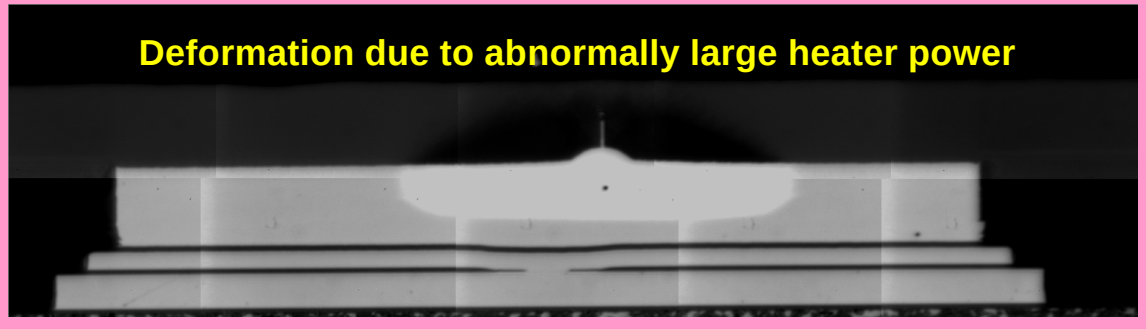
and some pin-flip and MRR change

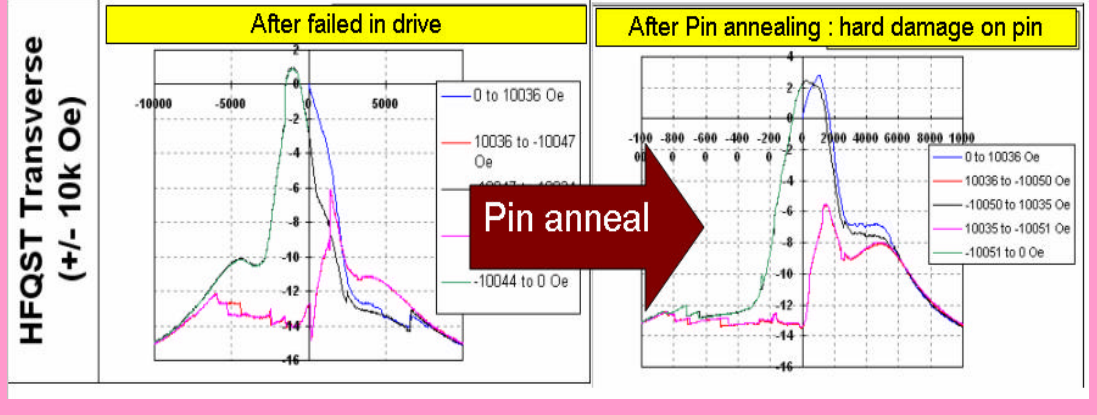
(1) Reader changes in drive reliability tests

Pin flipped and MRR changed







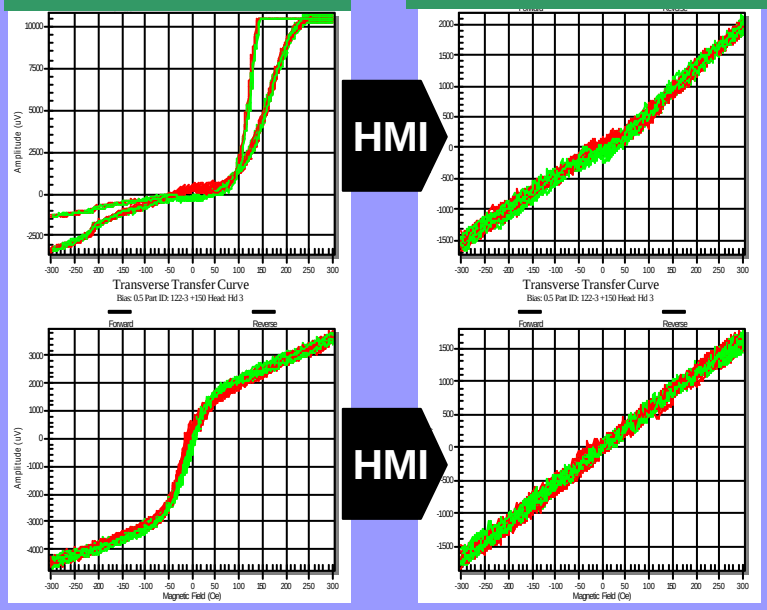


- Pin-flip and MRR change are due to HDI (head-disk interaction) &/or abnormally high heater power applied

(2) Recoverable or Non-recoverable by realigning HM

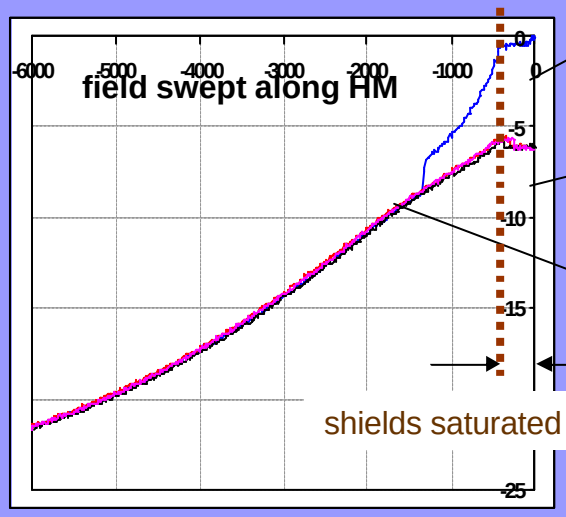
Failed in drive

Recovered by HMI



An example of recoverable HM distortion

2 cycles of 0 to 6kOe along HM



opening occurred in the 1st sweeping only

Y: reader response

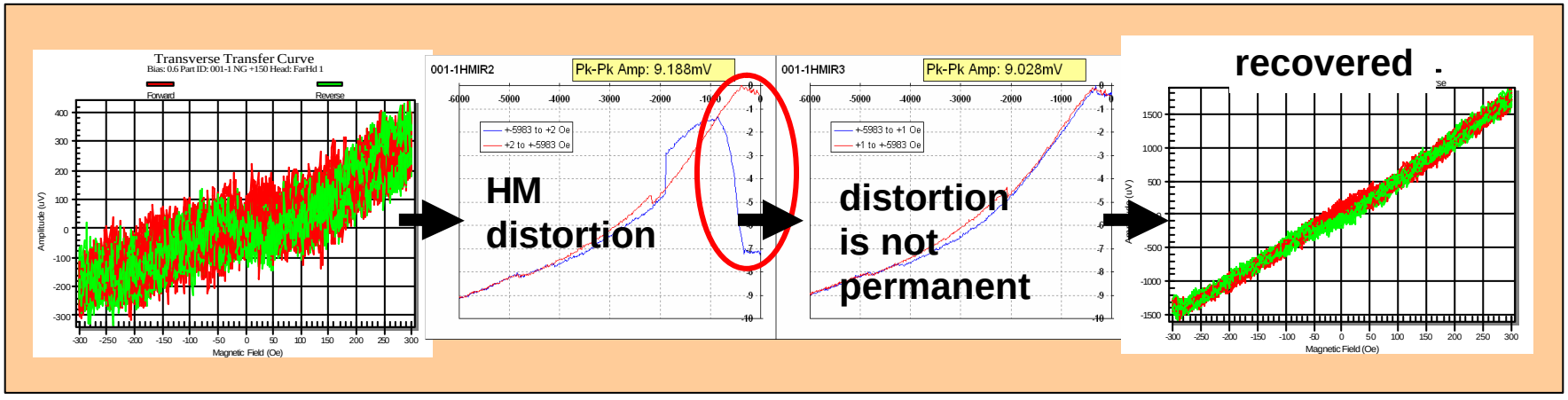
traces overlap in the 2nd sweeping, a recoverable HM distortion

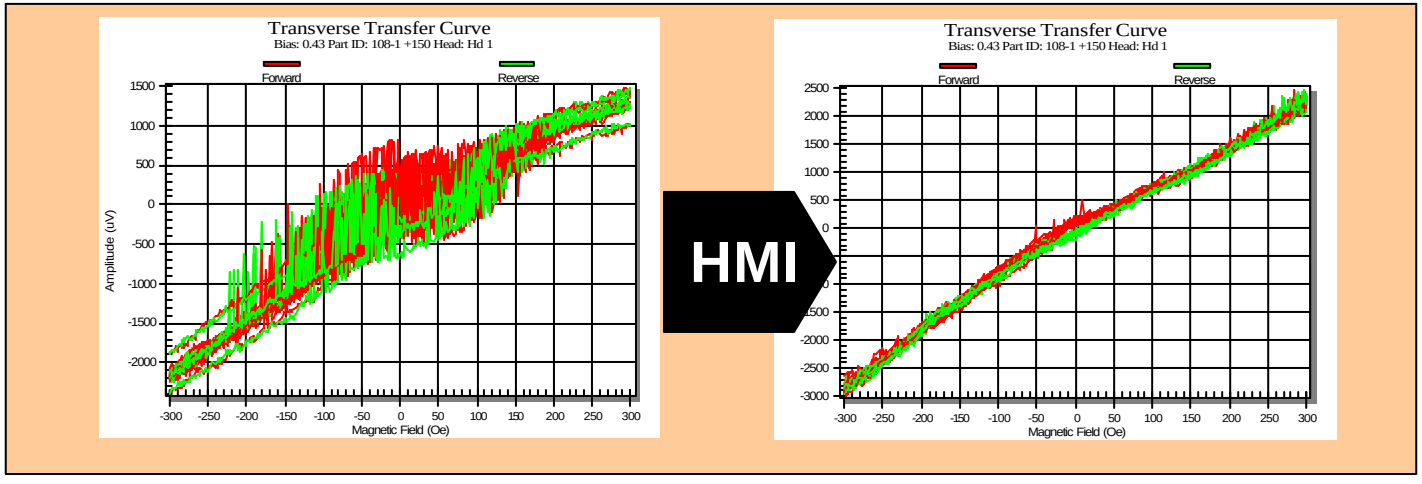
shields saturated at ~500 Oe

- Transfer curve change, without damage from e.g. HDI, are recoverable by HMI
- From HFQST analysis, the HM was distorted

(2) Recoverable or Non-recoverable by realigning HM

- Some failed from instability, especially when shown on transfer curves, are recoverable by HMI
- Instability resulted from HM distortion

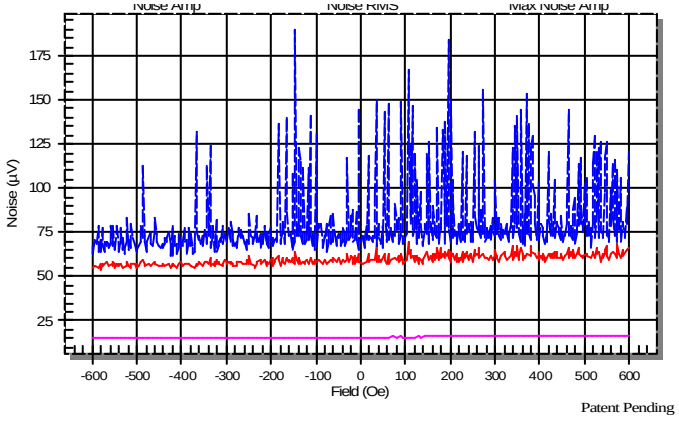




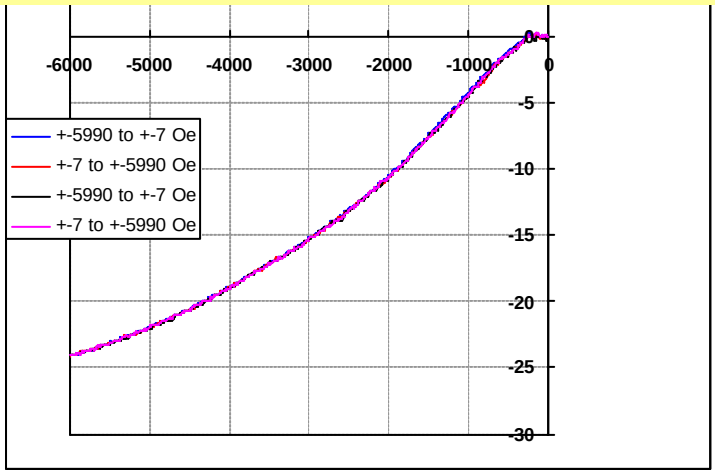
(3) Noise Non-recoverable by re-aligning HM

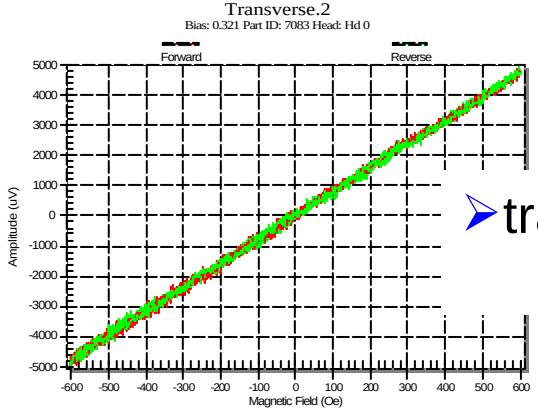
- For those failed from noise but non-recoverable by HMI, distortion in HM is not observed

SMAN on QST tester



0 to 6kOe swept along HM
2 cycles, all traces overlap



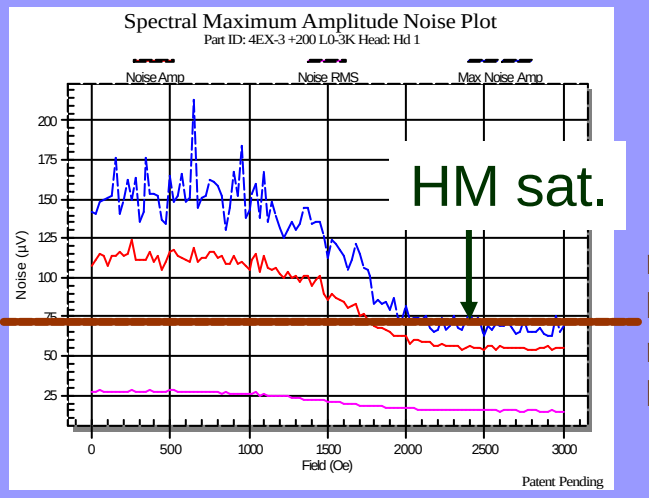


- transfer curve unchanged from shipment
  - ➔ No sign of weakened long. bias

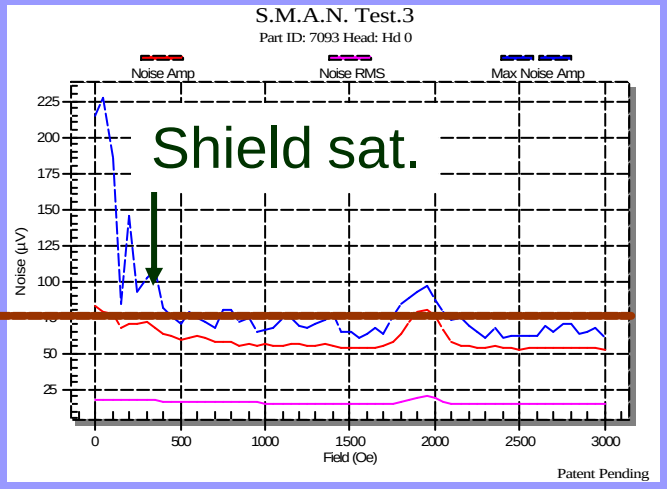
(3) Noise Non-recoverable by re-aligning HM

- For those failed from noise but non-recoverable by HMI, noise can be suppressed by in-situ field along HM
- When the field is withdrawn, noise comes back

- *With SMAN test on ISI2002 QST tester*
  (0~80MHz filter, with a 3kOe electromagnet)



noise level of normal heads



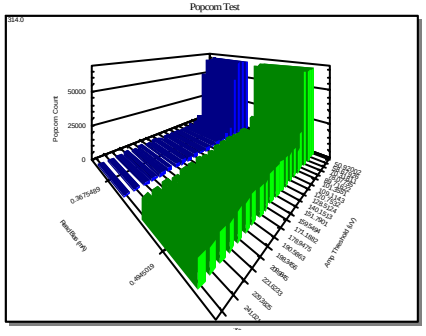
field applied along HM magnetization

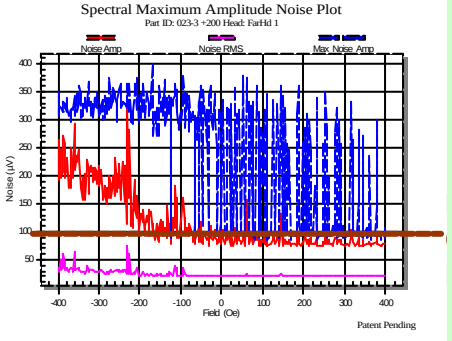
- HM & shield-HM are the parts giving rise to the noise

(3) Noise Non-recoverable by re-aligning HM

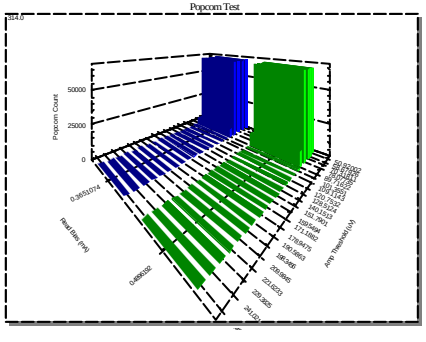
Effect of mild thermal stress

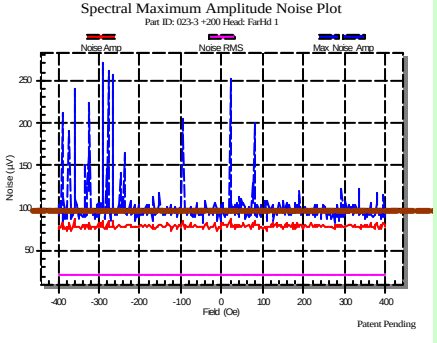
After re-aligning HM



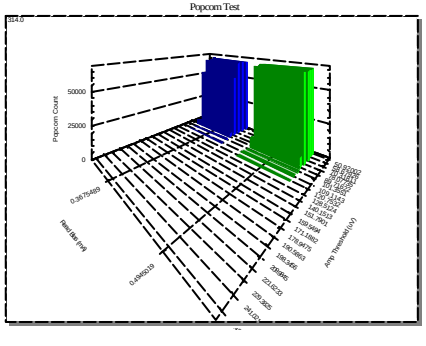


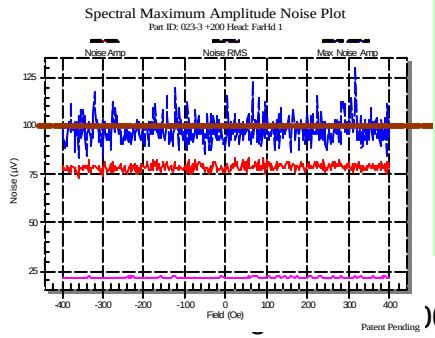
After 140C, 54hr





After 140C, 98hr





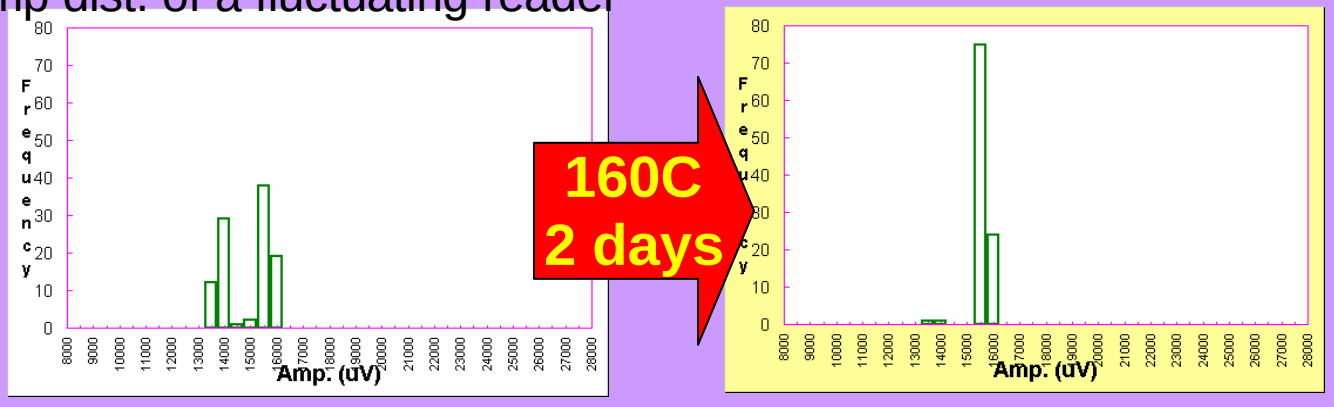
- Noise reduced gradually by mild thermal stress (Transfer curve unchanged in the thermal stress)
- implying that the degradation in HM is not a thermal driven process
- 140C does not make change in reader magnetics. The effect may come from change in mechanical stress in the reader.

(3) Noise Non-recoverable by re-aligning HM

Effect of mild thermal stress – what change made in HM ?

QST amp distribution in 100 times HMI (6kOe)

Amp dist. of a fluctuating reader



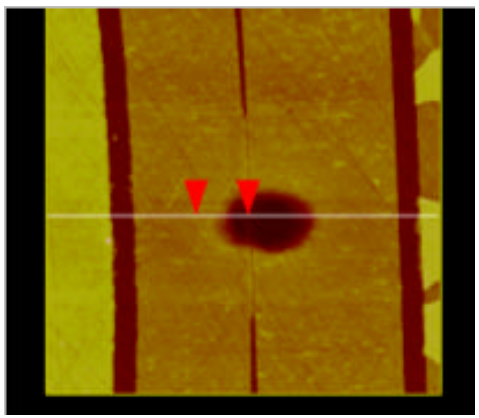
- *Before 160C, fluctuate between two alignments*
- *After 160C probability with in one of the alignments largely reduced*

- Mild thermal stress can reduce fluctuation in HM
- As no external field is applied during thermal stress, the stress is likely to have strengthened the anisotropy along the HM for parts 'loose' to the HM direction

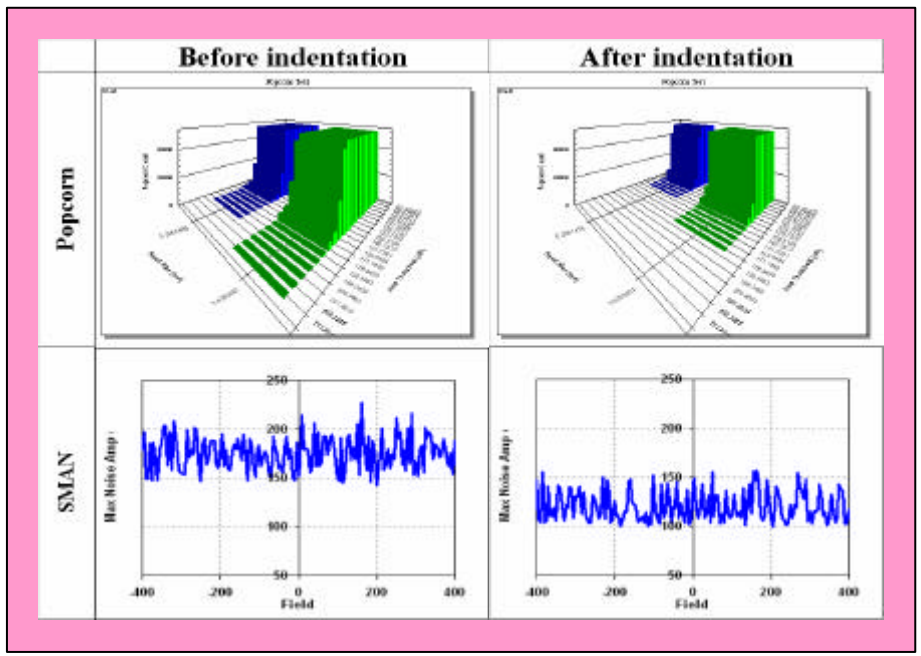
(3) Noise Non-recoverable by re-aligning HM

Effect of surface stress

- On the surface of failed readers, we made 4~6nm shallow deformation over large area compared to reader dimensions, with nano-indentor (tip diameter 5um)



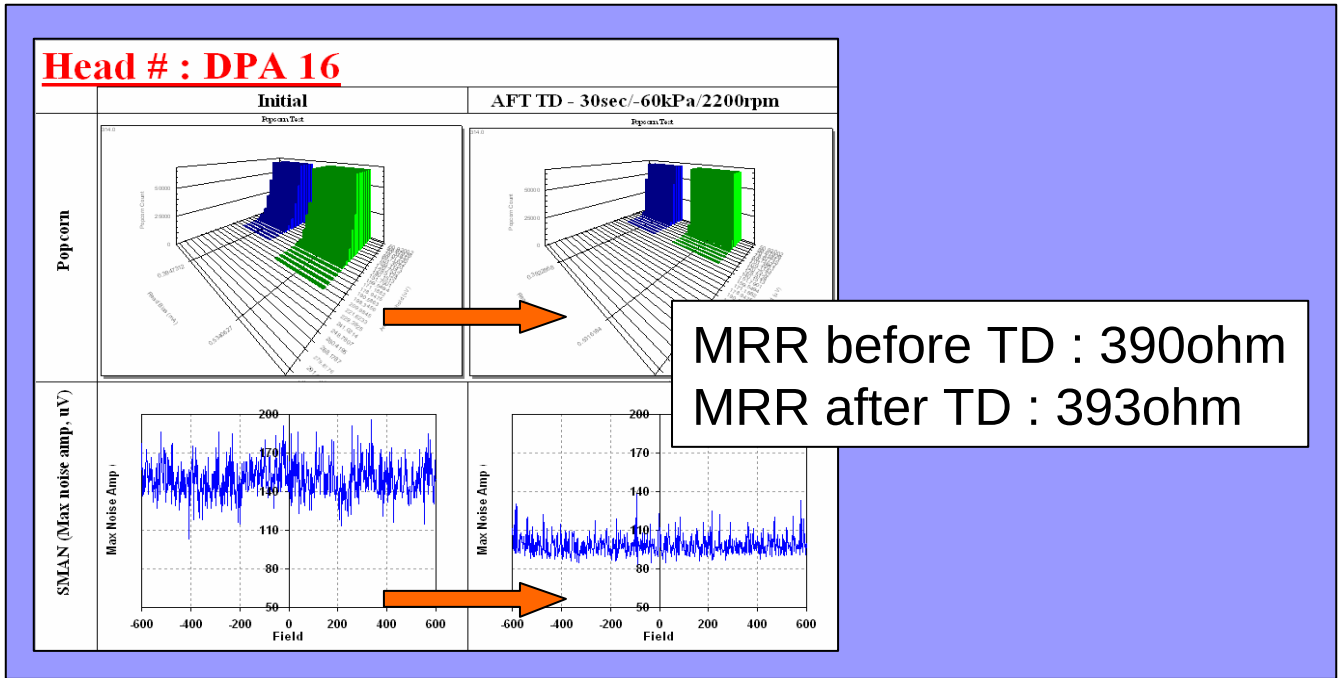
shallow indent on large region covering reader



- All the failed heads have noise either removed or significantly reduced
- The noise is sensitive to the condition on surface

(3) Noise Non-recoverable by re-aligning HM

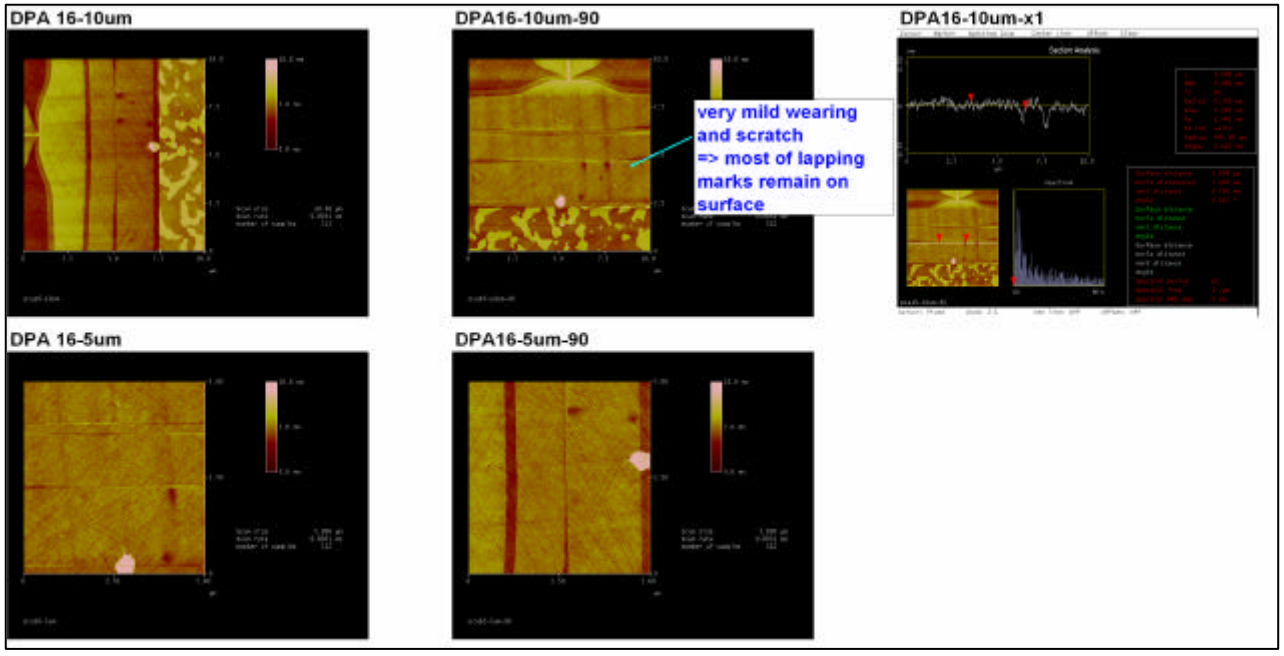
Effect of wearing on media



- Head touch-down (TD) on media with low pressure & low RMP, to make touching on reader region
- No significant MRR change, implying no significant wear on reader
- Yet noise reduced to normal level

(3) Noise Non-recoverable by re-aligning HM

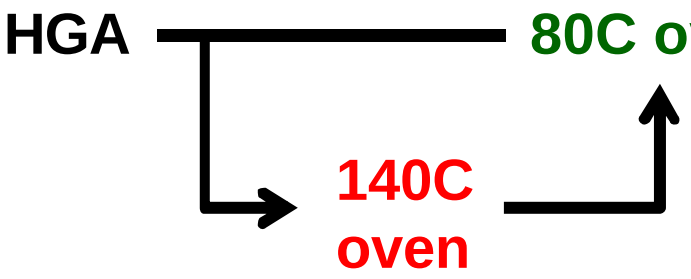
Effect of wearing on media



- AFM showed that the touch-down did not create wear significantly deeper than the lapping roughness
- Yet noise reduced to normal level
- The noise is dependent on condition of the surface (~1nm down)

(3) Noise Non-recoverable by re-aligning HM

Releasing stress for better reliability



count for noise increased

80C x (4+4) days to simulate drive ambient

** Noise measured by SMAN (ISI2002, 80MHz filter, +/-600Oe),* ***counted those with 10% noise increase***

Gp	140C Treatment Time	Sample Size	Noise increased After 80C 4+4days Cooking
OV1	1hr	558	1.61%
OV6	6hrs	559	1.43%
OV12	12hrs	553	1.13%
OV24	24hrs	573	0.35%

- Effect increases with time, indicating a slow relaxation process

Conclusions

Among the common failure modes of TMR failure in drive reliability tests, we analyzed the noise non-recoverable by HMI (without HDI),

(1) The noise is related to change in HM in drive

(2) Stress on surface is the cause of changes

(3) 'Releasing' stress before drive tests can largely reduce the chance of noise occurrence in drive

Thank you !