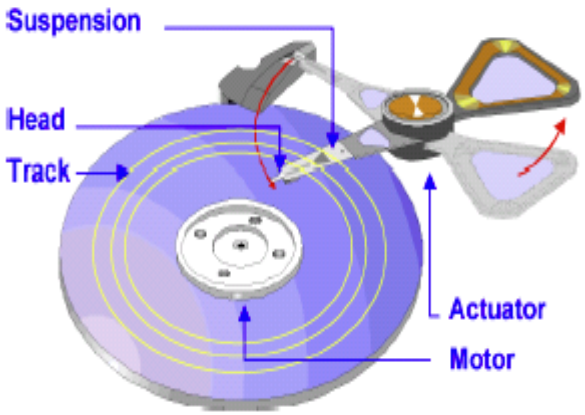
HGST
a Western Digital company

Thin Film Application in Magnetic Recording

Zheng Gao,
Read Head Development team
Hitachi Global Storage Technology

Company of Vertical Drive Integration

Recording Head/Media are Built on Thin Film and Nano Technology



Media MFG

Head Wafer MFG- San Jose/JP

Head Slider MFG

Drive Assembly

HDD Testing and Integration

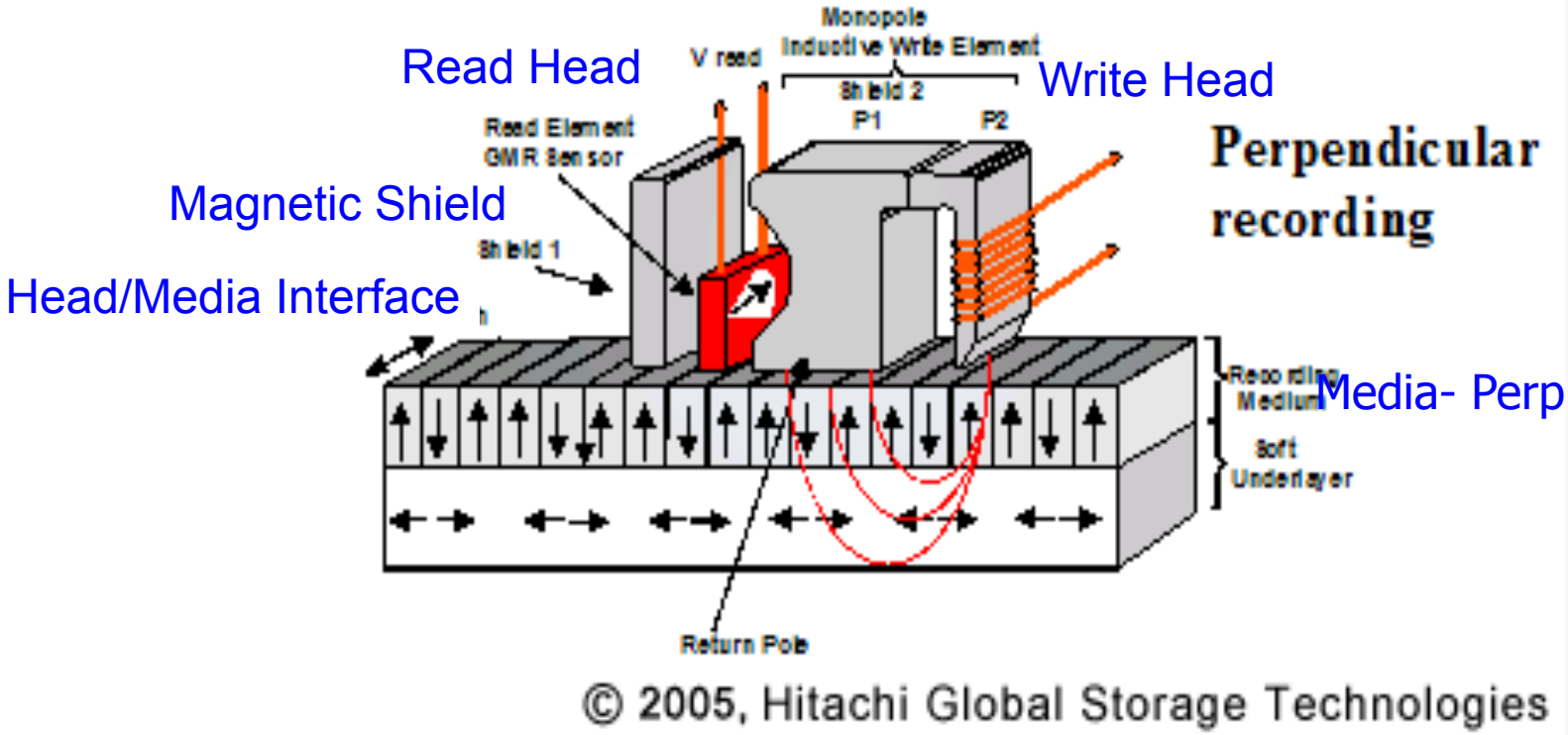
Servo/Channel

Category	Drive ID	Speed	Size	Max Capacity	AreaDensity
Enterprise	Ultrastar 15K600	15000rpm	3.5inch	600GB	
	Ultrastar C10K1200	10000rpm	2.5inch	1.2TB	448Gb/in.sq
	Ultrastar 7K1201	7200rpm	3.5inch	4TB	446Gb/in.sq
Mobile	Travelstar 5K1000	7200rpm	2.5inch	1TB	676Gb/in.sq
	Travelstar 7K1000	5400rpm	2.5inch	1TB	694Gb/in.sq
DeskTop	DeskStar 7K1000.C	7200rpm	3.5inch	1TB	352Gb/in.sq
Consumer Electronics	CinemaStar Z7K500	7200rpm	2.5inch	500GB	630Gb/in.sq
	CinemaStar V5K1000	5400rpm	2.5inch	1TB	694Gb/in.sq
Automotive Industrial	Endurastar N4L100	4000rpm	2.5inch	100GB	172Gb/in.sq
	Endurastar J4K100	4000rom	2.5inch	100GB	172Gb/in.sq

Perpendicular Recording Head and Media

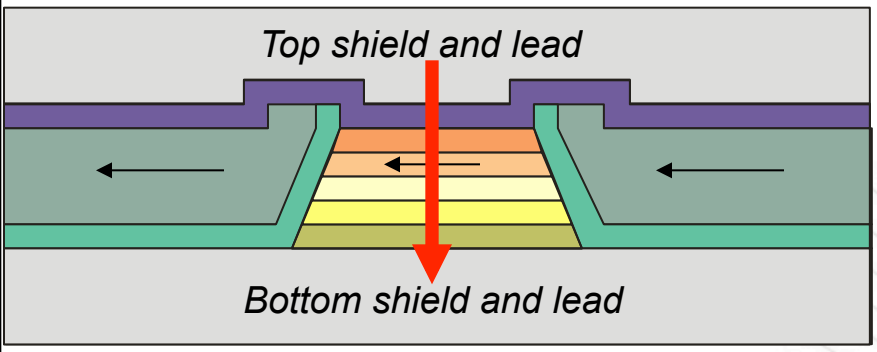
Read Sensor is Key Element in Read Head to Sense Media Signal by Resistance Change.

Read Sensor: Tunneling Magnetoresistive Sensor TMR



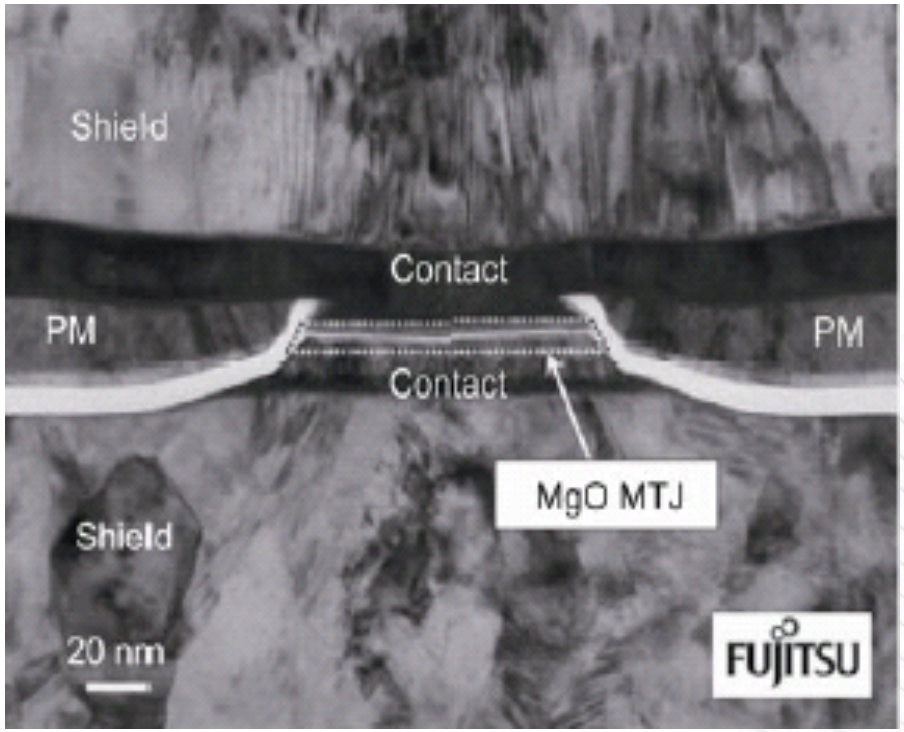
Read Head Structure and Wafer Build

Building Read Head



1. Deposit Multilayer Sensor Stack
   (15-22 PVD Layers in 4-80 Å Level)
2. 193 Photo Mask for Critical Dimension
   (25-50nm Track Width)
3. Ion Mill or RIE Pattern Transfer
4. ALD Isolation and Hard Bias Stack
5. Liftoff
6. RIE Clean
7. Top Contact
8. Top Shield Plating

Read Head and Read Sensor



Fujitsu Reader TEM Image

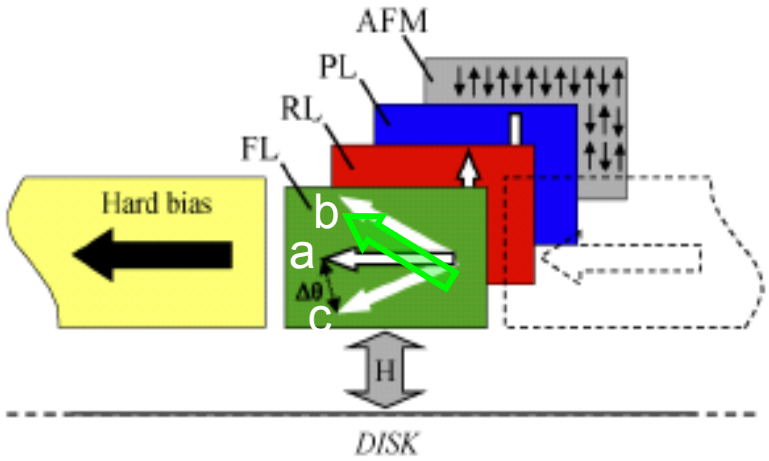
250GB Earlier Generation Head;

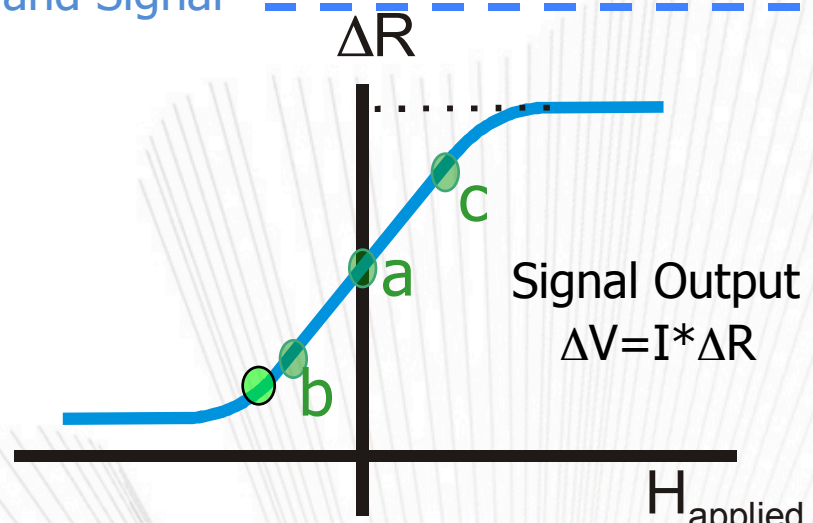
Sensor Total Thickness 35nm.

Sensor/Junction/ Isolation/HB/Shield

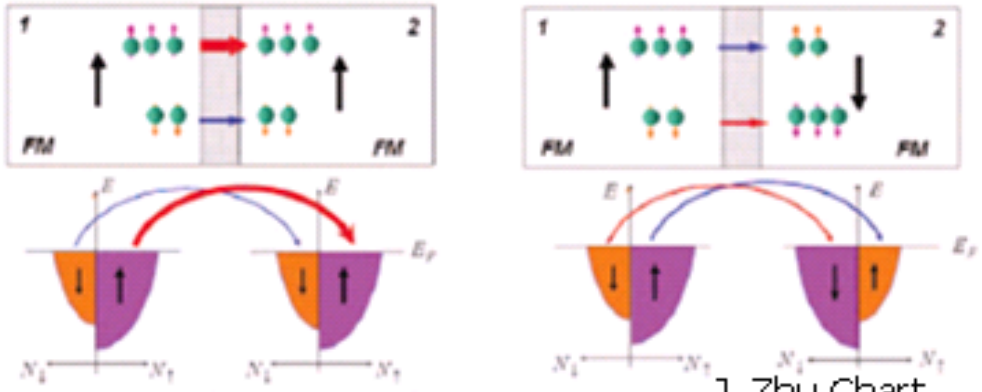
Read Head/TMR Sensor Working Principle

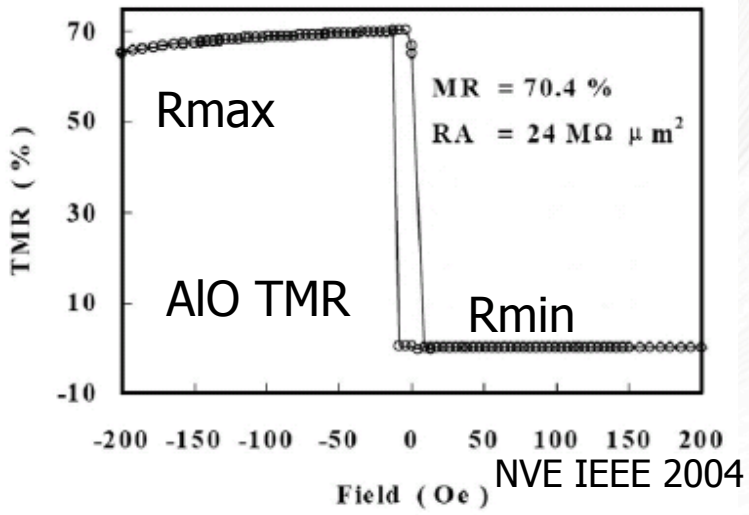
Reader Magnetic Config and Signal



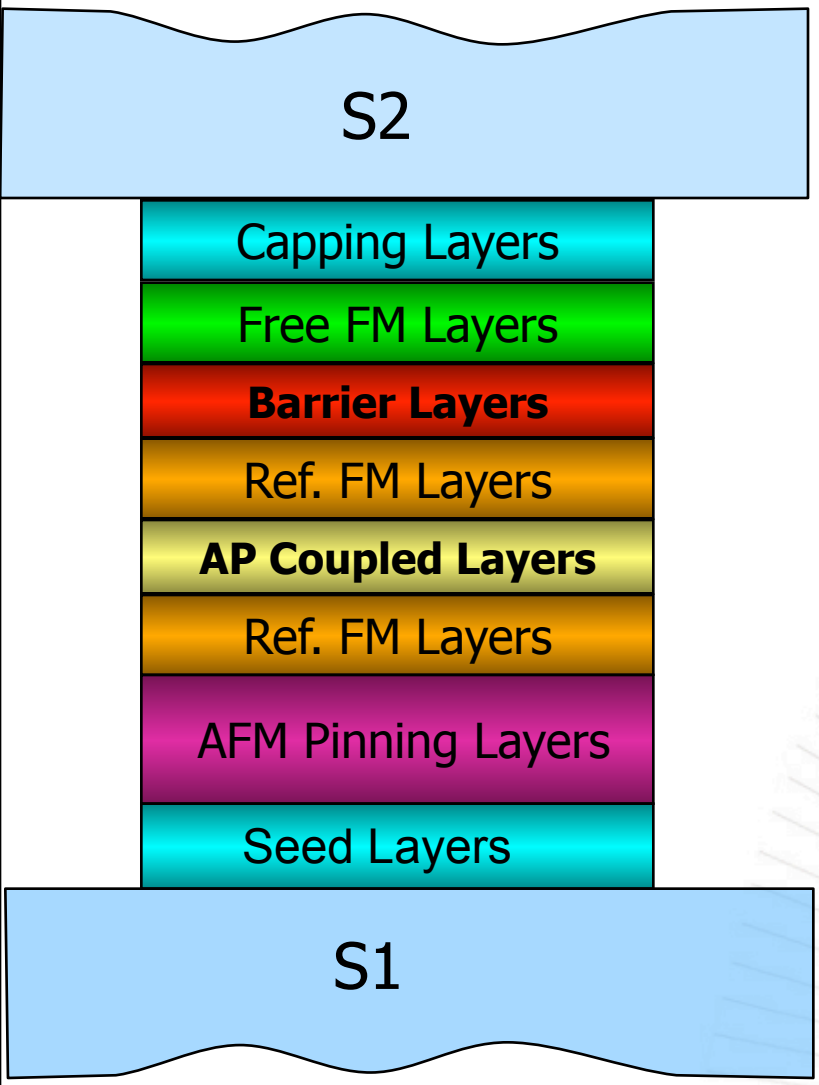


TMR (Tunneling Magnetoresistive) Field-Resistance Sensor





Read Sensor General Structure and Function



Capping Layer: (10-50Å; 1-3 Layers)

Free FM Layer: (30-80Å; 1-5 Layers)

Barrier Layers: (~10Å; 1-4 Layers)

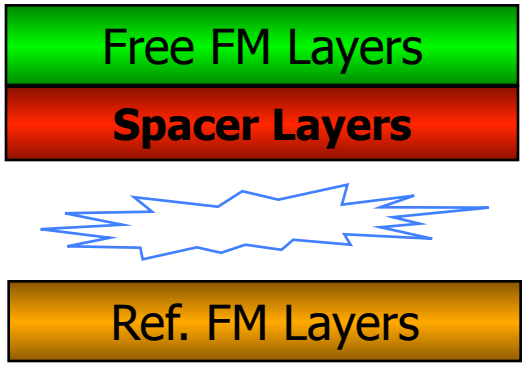
Ref.+Pinned Layers: (~30-60Å; 2-10 Layers)

AFM Pinning Layer: (40-80Å; 1 Layer)

Seed Layers: (> 20A, 2-5 Layers)

All Layers (>20) are Deposited in PVD Cluster w/o Vacuum Break (BP 5E-09)

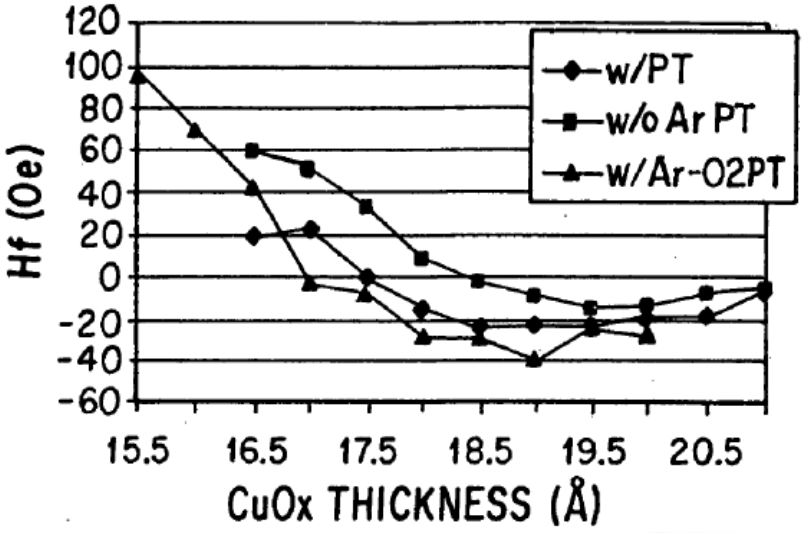
Thin Film Plasma Treatment

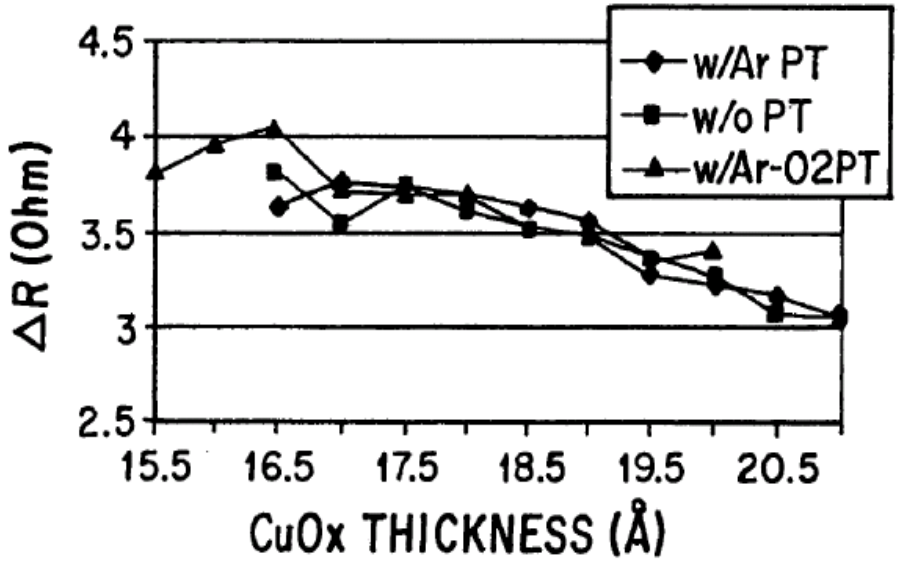


Low Power Plasma Treatment
Smoothes Film w few Å Removal

Hf Reduction and MR ratio Improvement:

Ref Layer (~20Å) Roughness Reduction;
High Quality Growth of Spacer layer;
Improve Density and Resistivity of Ref FM Layer.



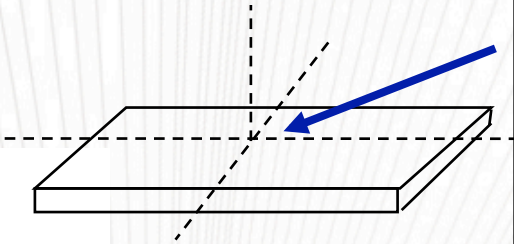


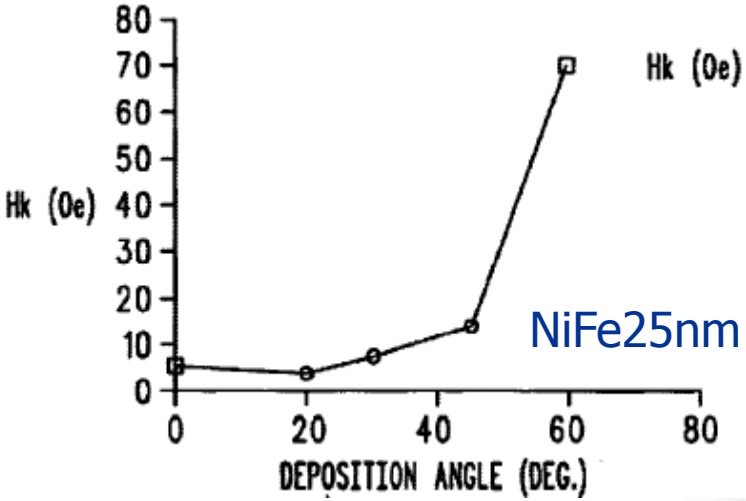
US Patent 026470A1 2004 IBM

Thin Film Oblique Deposition

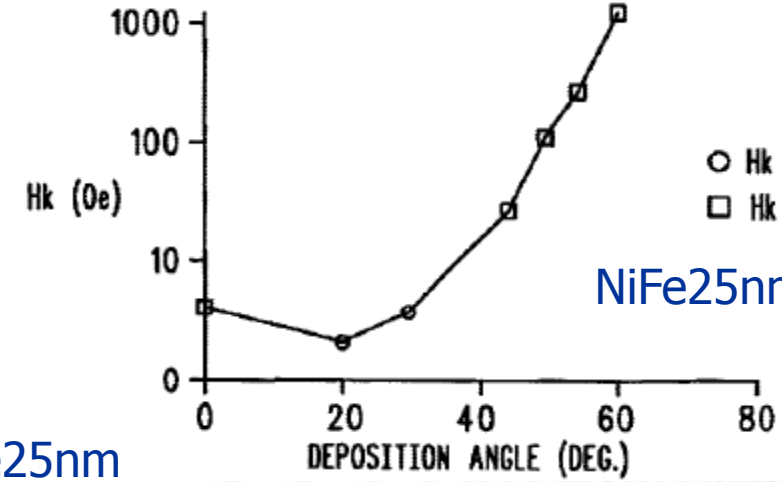
Magnetic Anisotropy is Important for Both Reader and Writer.

Oblique Deposition { Surface Morphology; Strain Anisotropy ⇒ Induced Magnetic Anisotropy; Microstructure/Orientation





NiFe25nm



NiFe25nm/Ta25nm

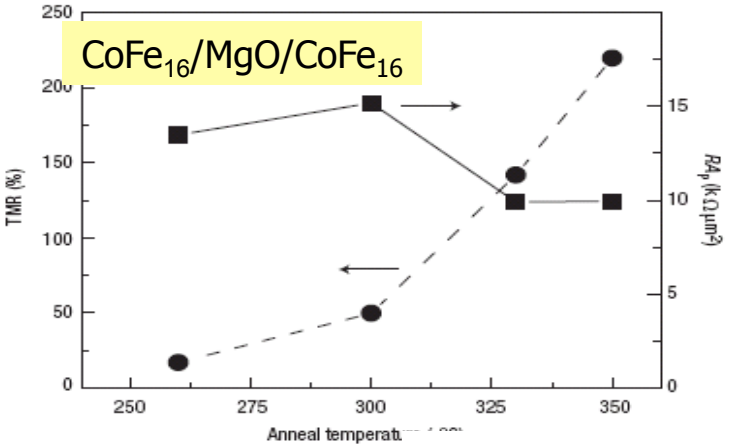
US Patent 6818961B1, Freescale, Filed 2003

NiCo Oblique, CNRS France, J. Appl. Phys 1992

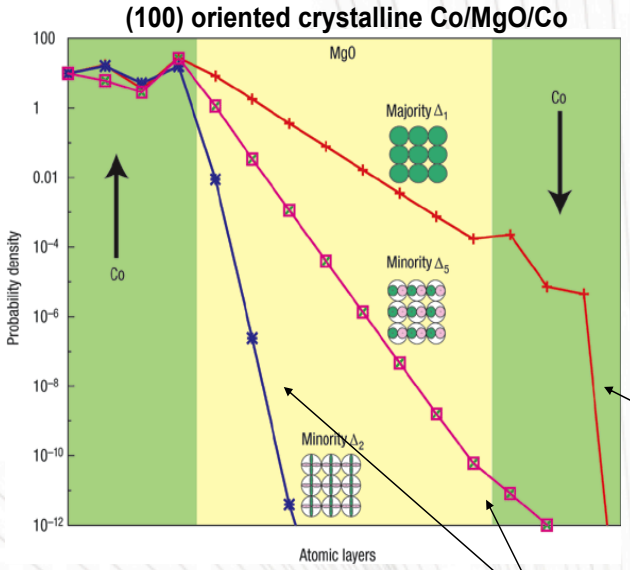
Strong Anisotropy on Oblique Ta, NIST, J. Appl. Phys 2000

TMR Barrier from Year 2004

Large MgO TMR Ratio Observed due to Spin Filtering Effect



IBM S.Parkin 2004



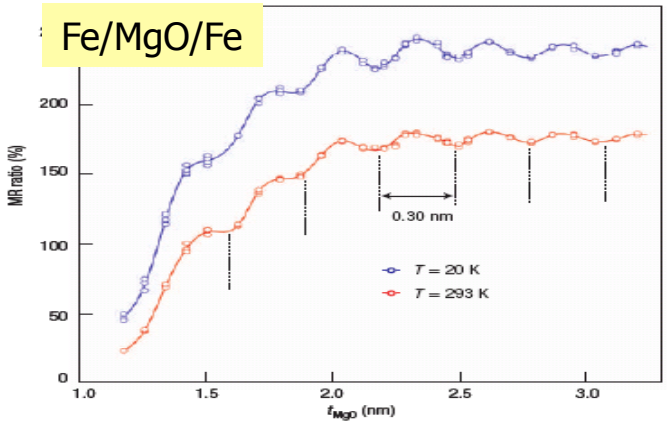
-Crystalline MgO barriers act as a spin filter → Large TMR (> 100%).

- Low electron effective mass → Low electrical resistance

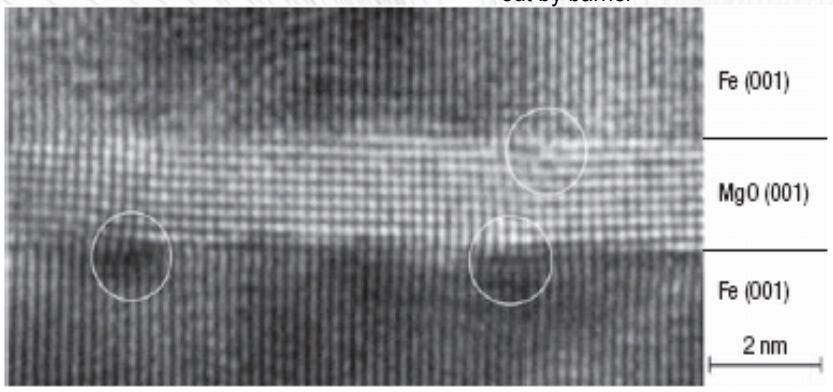
W.Butler, Zheng et al 2001/ 2004

Δ_1 state decays rapidly in antiparallel alignment

Δ_2 and Δ_5 states are filtered out by barrier



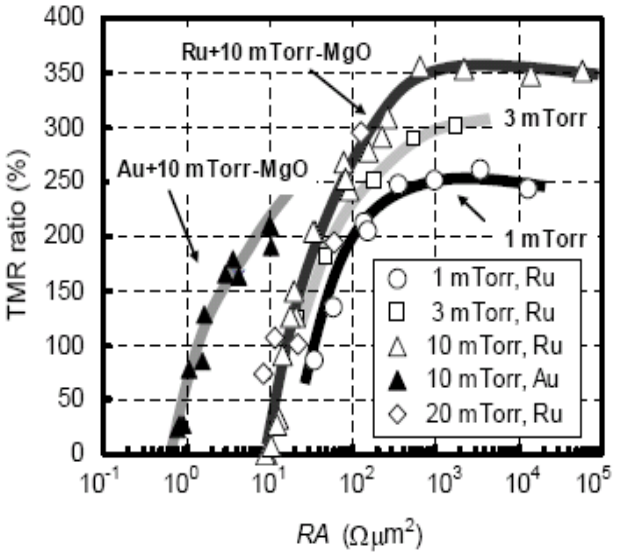
AIST Y. Yuasa 2004



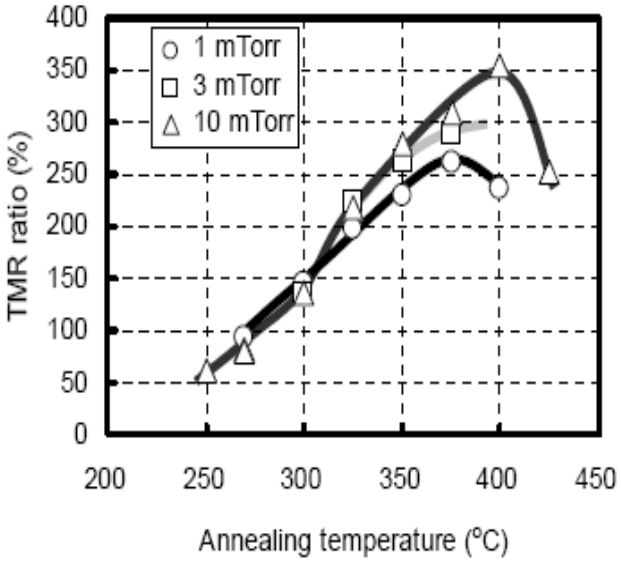
Thin Film Read Magnetic Sensor

MgO TMR Ratio Highly Sensitive to

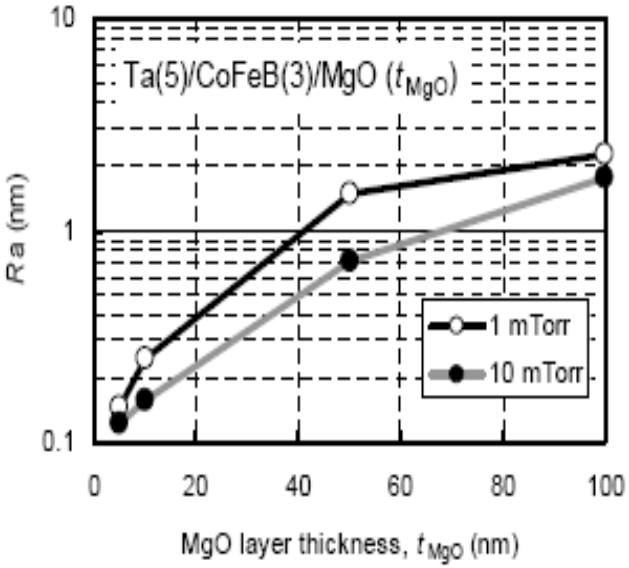
Barrier Process and Chamber Condition /Target Quality



Sputter Condition



Annealing Condition



Surface Roughness

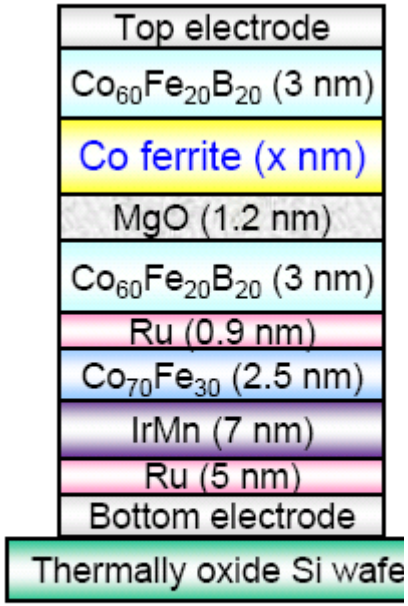
Stack:Sub/Ta5/UL50/Ta5/NiFe5/IrMn8/CoFe2/Ru8/CoFeB3/MgO/CoFeB30/Ta5/Ru15 (nm)

Tohoku Univ. and Hitachi Ltd.

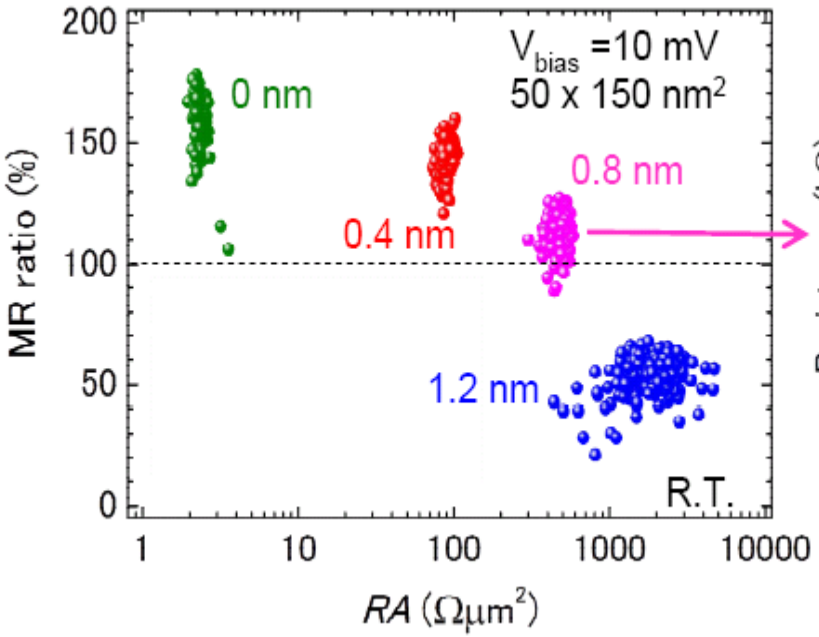
Thin Film Read Magnetic Sensor

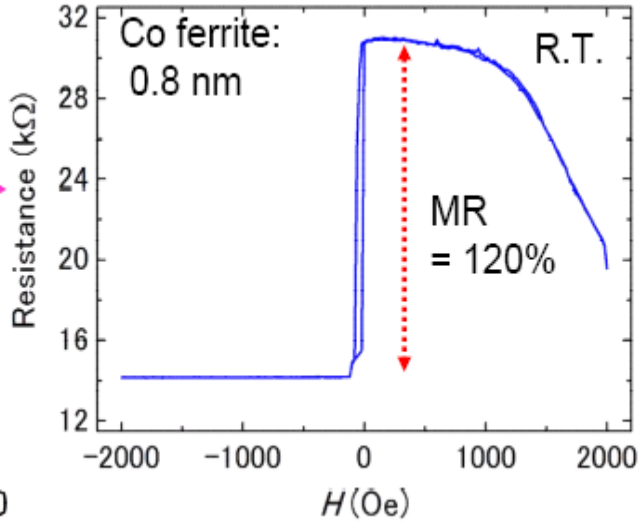
MgO RA MR Ratio are Highly Sensitive to

Interface Material and Structure in Atomic Level



Stack configuration
Anneal: 360 °C, 2 h, 1





Intermag Jan 2013 Anelva

PVD Tools for Magnetic Sensor

Anelva 7100

Ulvac ENTRON™-EX

Singulus TIMARIS

- Multiple DC/RF Cathode
- Ultra High Vacuum (-9 to -10 Torr)
- Angstrom level of control with uniformity
- Wafer Size 150mm to 300mm

Summary

HDD is Abundant with Every Engineering Discipline

Thin Film Magnetics and Micro Fabrication Process Play Important Role in Recording Head Build and Head Performance

Thank You