



Thin Film Application in Magnetic Recording

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Read Head Development team
Hitachi Global Storage Technology**



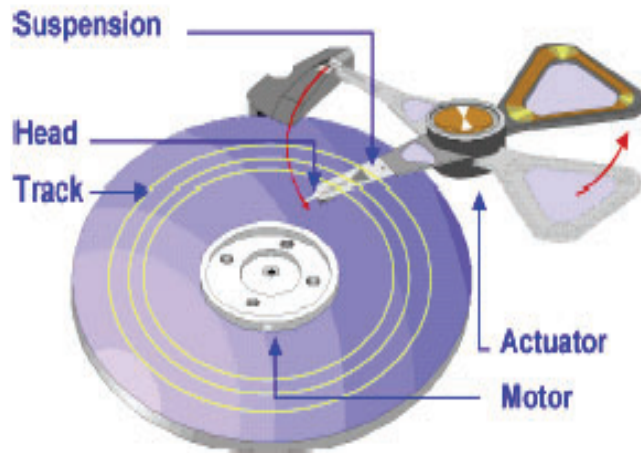
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AVS North America Plasma Application 4-2013

IP Bridge Exhibit 2043
Western Digital v. IP Bridge
IPR2025-00701

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



Media MFG

Head Wafer MFG- San Jose/JP

Head Slider MFG

Drive Assembly

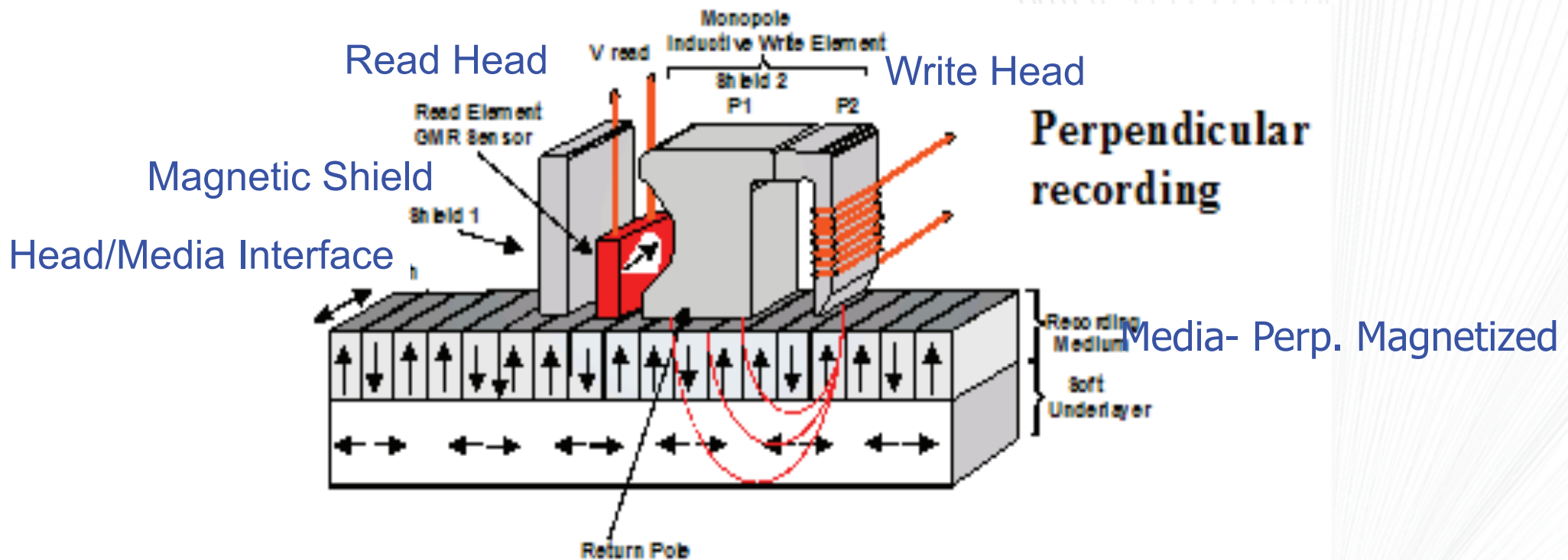
HDD Testing and Integration

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	4000rpm	2.5inch	100GB	172Gb/in.sq

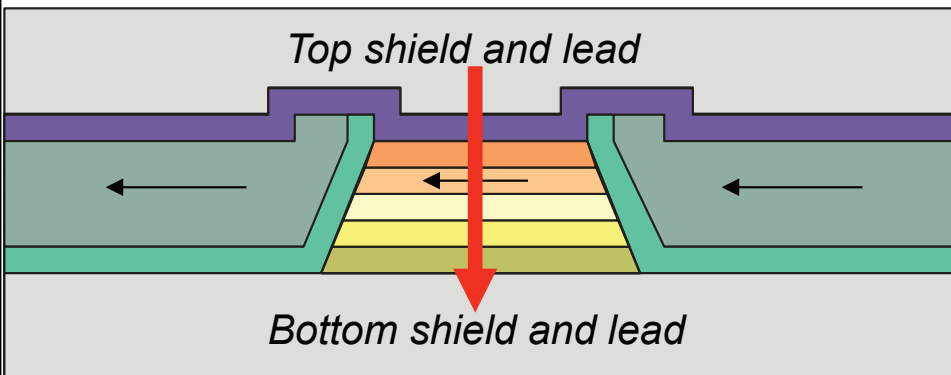
Read Sensor is Key Element in Read Head to Sense Media Signal by Resistance Change.

Read Sensor: Tunneling Magnetoresistive Sensor TMR

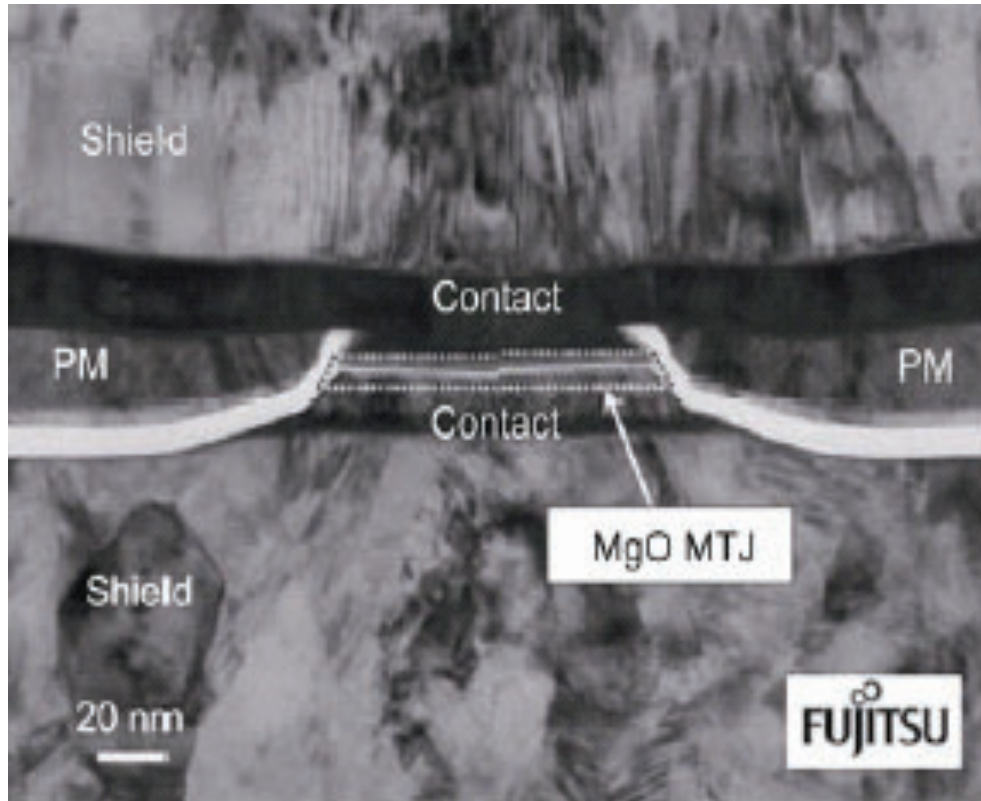


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Building Read Head



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

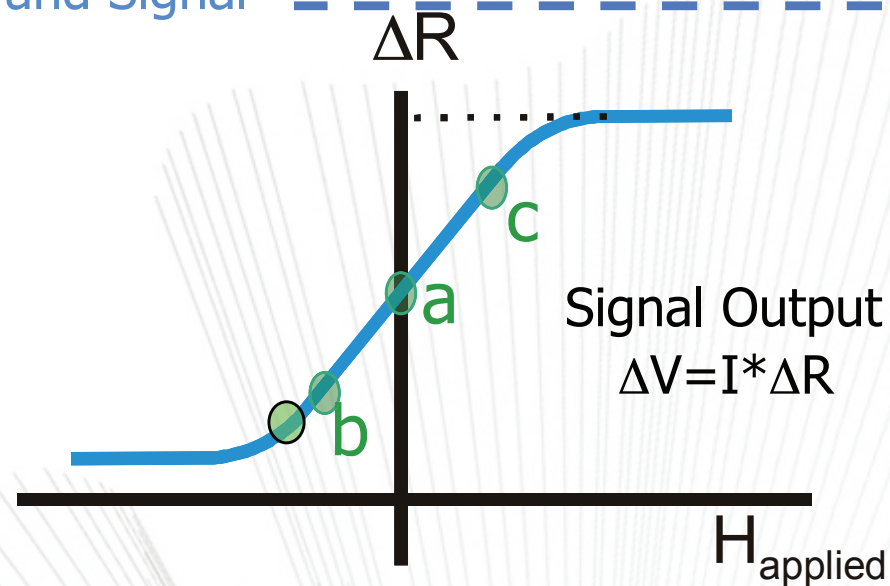
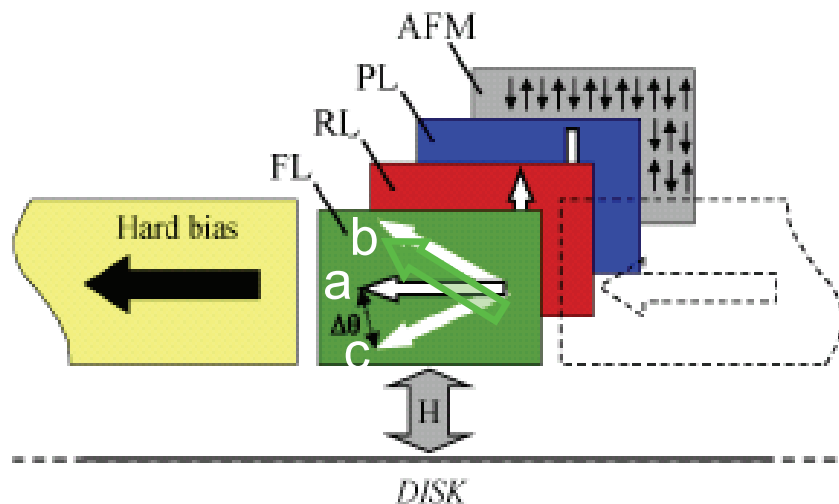


Fujitsu Reader TEM Image

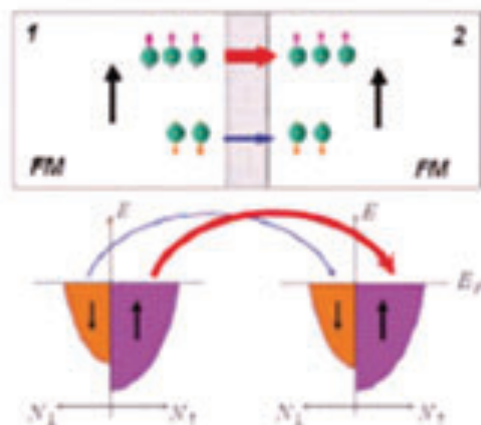
250GB Earlier Generation Head;
Sensor Total Thickness 35nm.

**Sensor/Junction/
Isolation/HB/Shield**

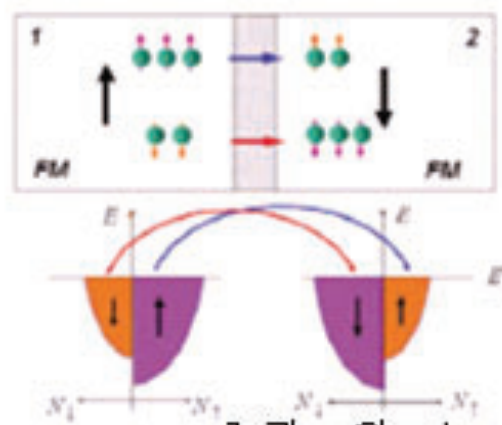
Reader Magnetic Config and Signal



TMR (Tunneling Magnetoresistive) Field-Resistance Sensor

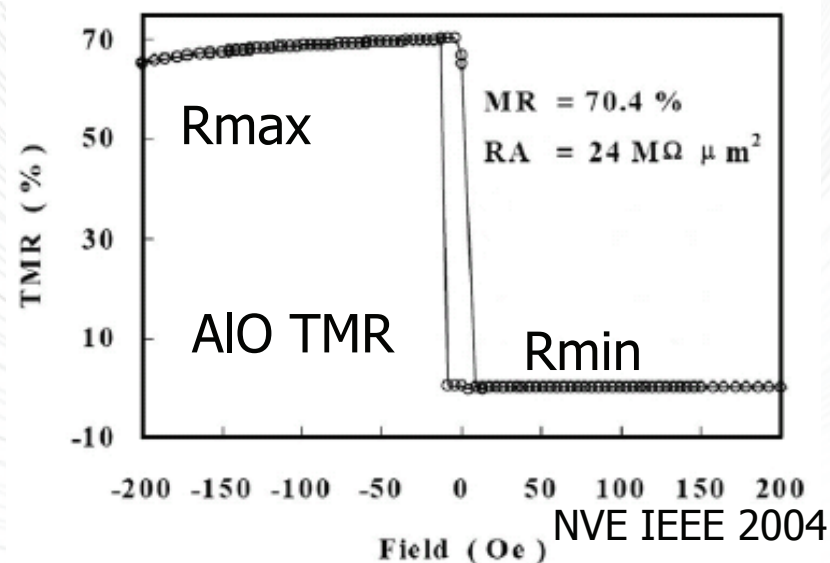


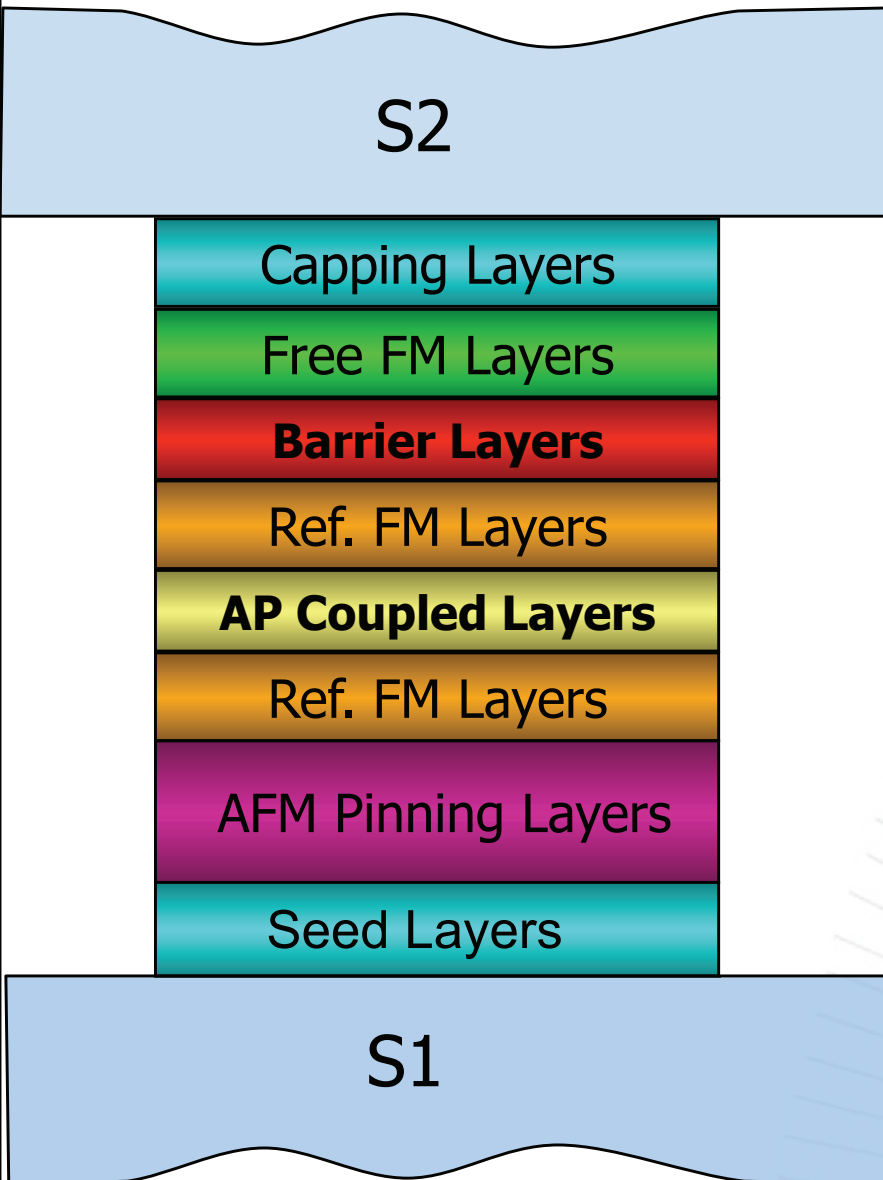
FM1 // FM2



FM1 anti//FM2

J. Zhu Chart





Capping Layer: (10-50Å; 1-3 Layers)

Free FM Layer: (30-80Å; 1-5 Layers)

Barrier Layers: ($\sim 10\text{\AA}$; 1-4 Layers)

Ref.+Pinned Layers: ($\sim 30-60\text{\AA}$; 2-10 Layers)

AFM Pinning Layer: (40-80Å; 1 Layer)

Seed Layers: ($> 20\text{\AA}$, 2-5 Layers)

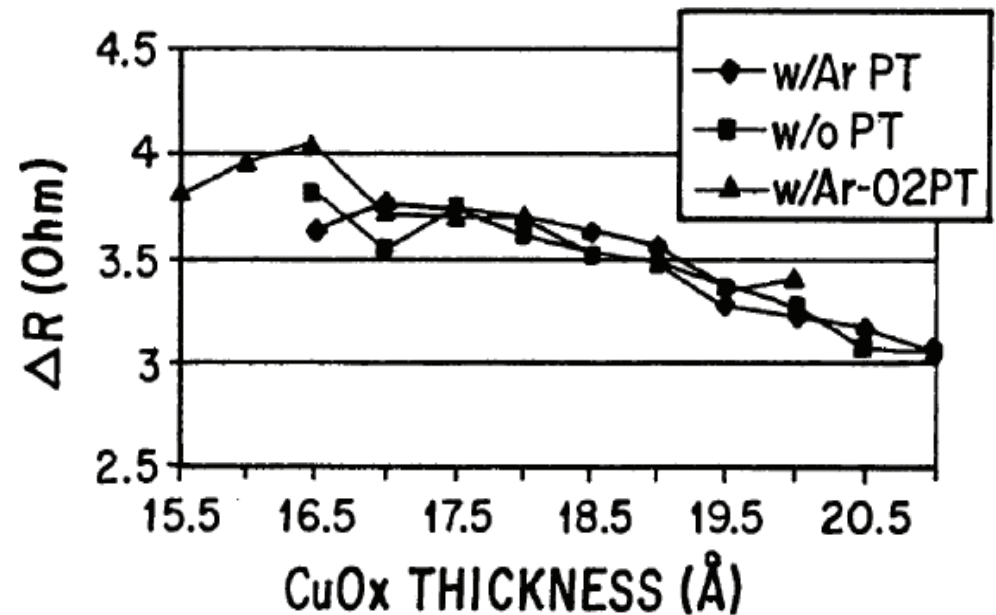
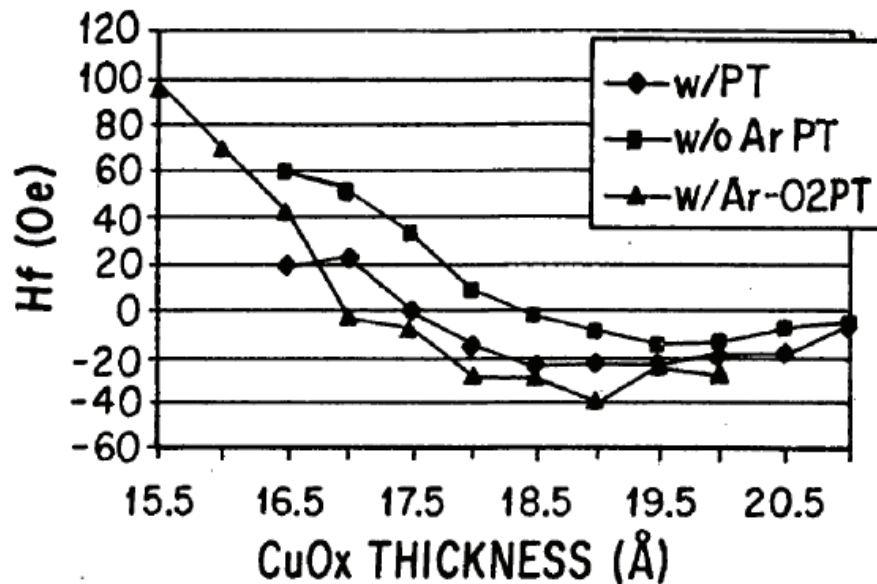
All Layers (>20) are Deposited in PVD Cluster w/o Vacuum Break (BP 5E-09)

Low Power Plasma Treatment Smooths Film w few Å Removal



Hf Reduction and MR ratio Improvement:

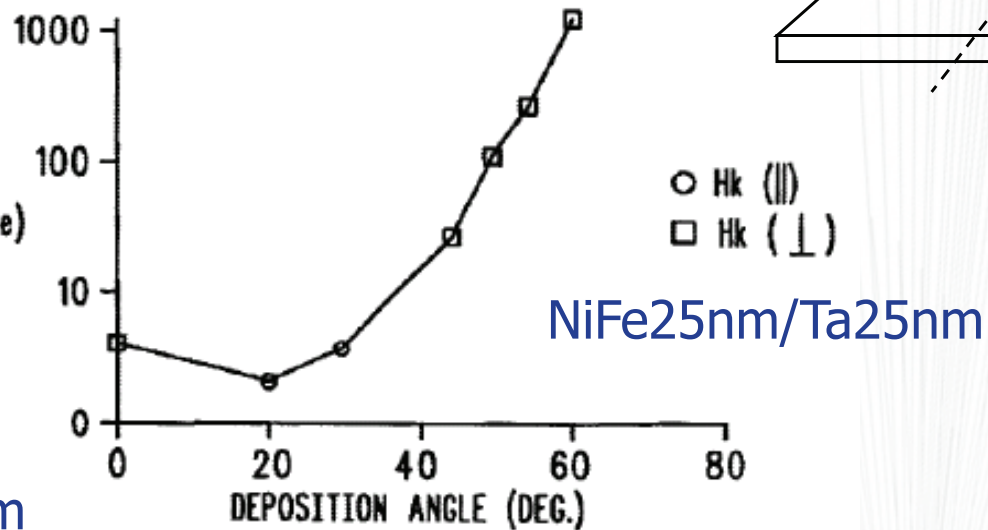
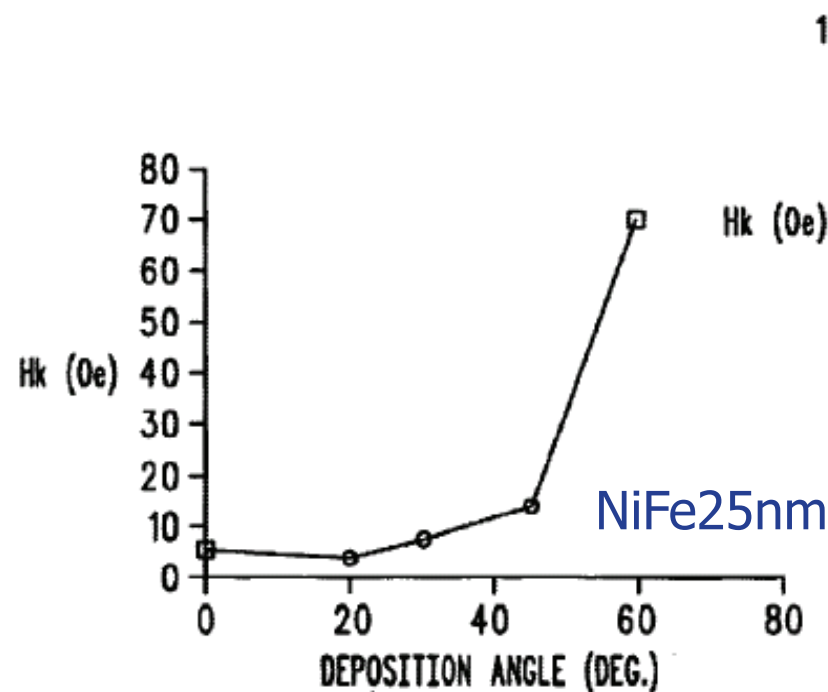
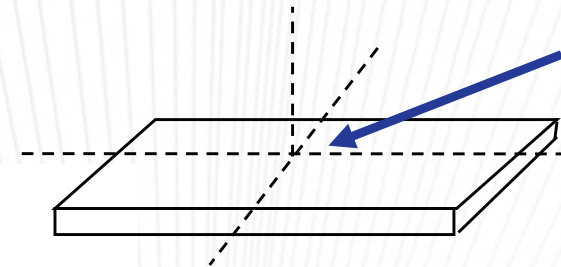
Ref Layer ($\sim 20\text{\AA}$) Roughness Reduction;
High Quality Growth of Spacer layer;
Improve Density and Resistivity of Ref FM Layer.



US Patent 026470A1 2004 IBM

Magnetic Anisotropy is Important for Both Reader and Writer.

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

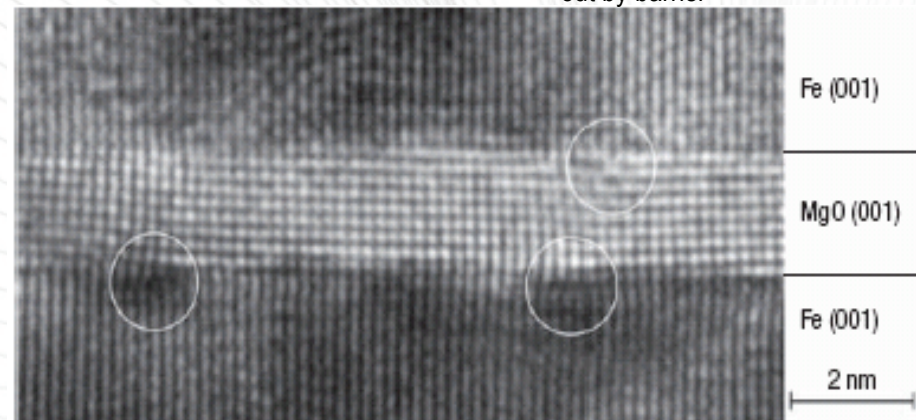
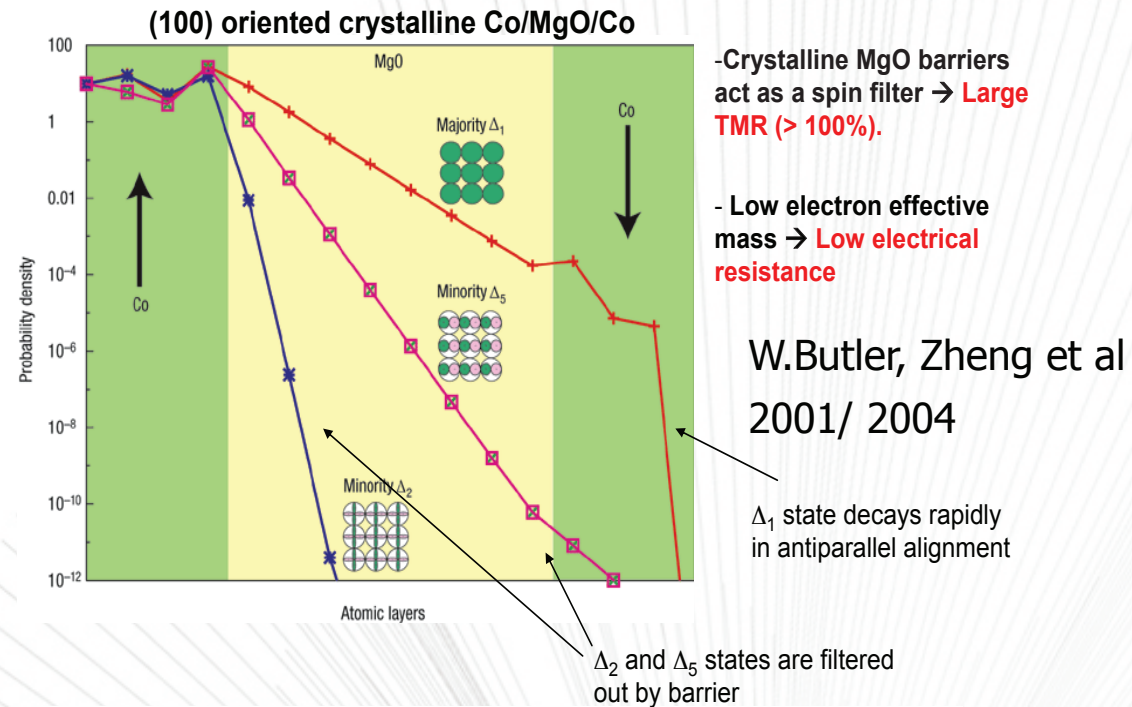
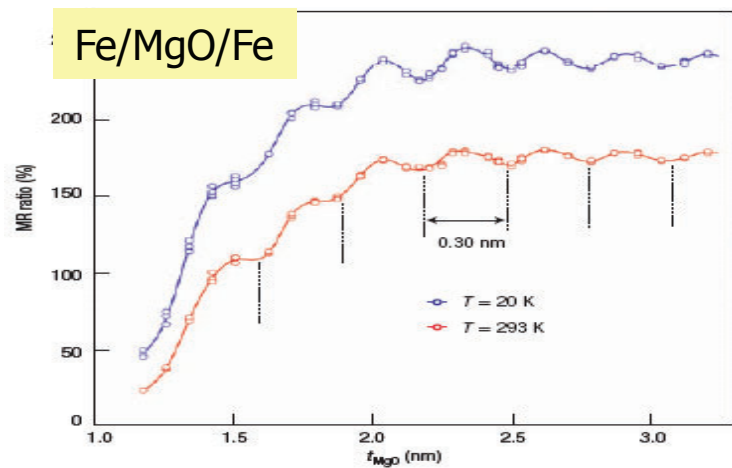
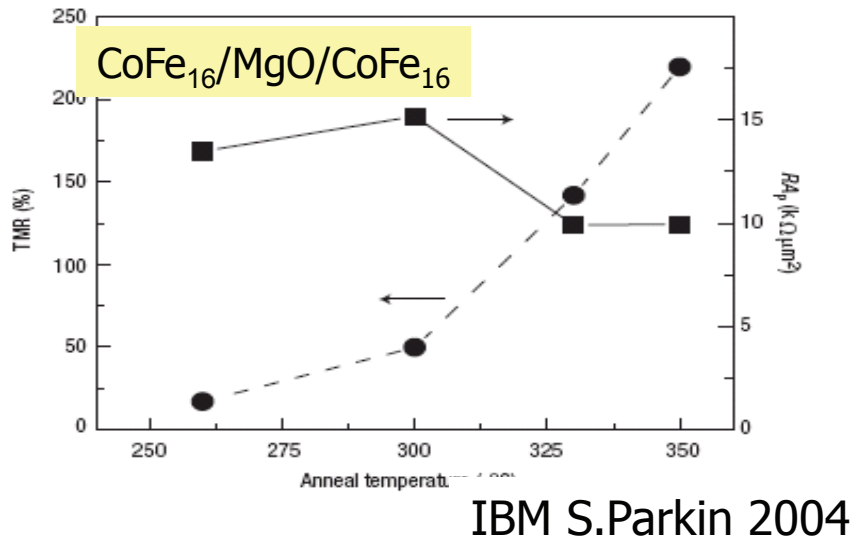


US Patent 6818961B1, Freescale, Filed 2003

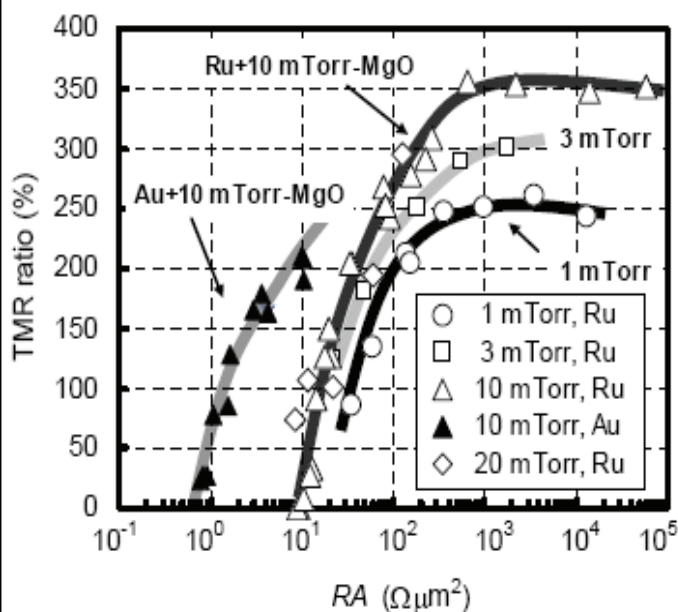
NiCo Oblique, CNRS France, J. Appl. Phys 1992

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

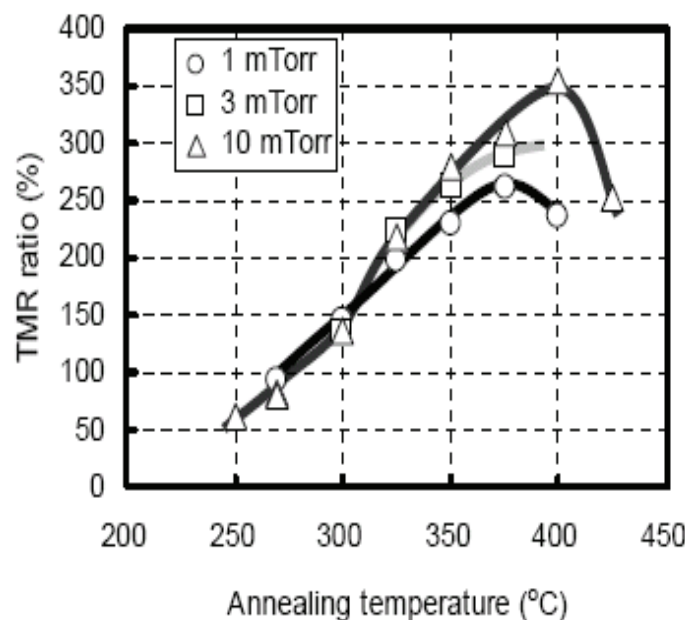
Large MgO TMR Ratio Observed due to Spin Filtering Effect



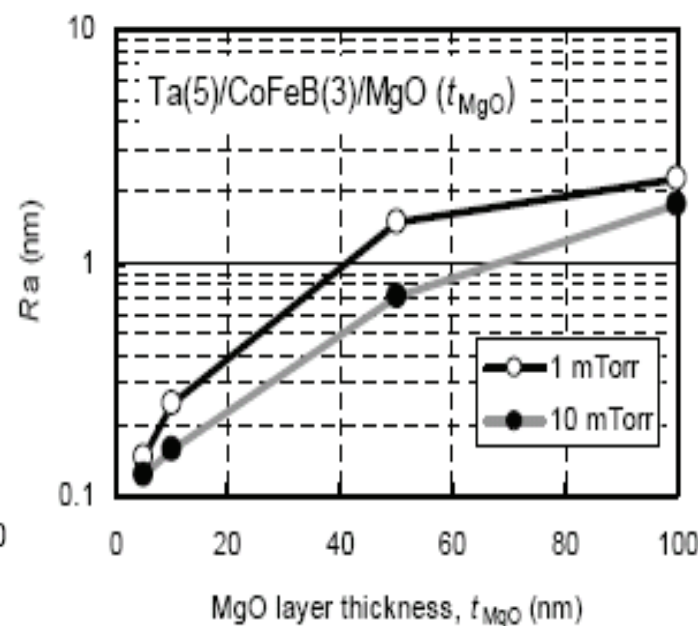
MgO TMR Ratio Highly Sensitive to Barrier Process and Chamber Condition /Target Quality



Sputter Condition



Annealing Condition



Surface Roughness

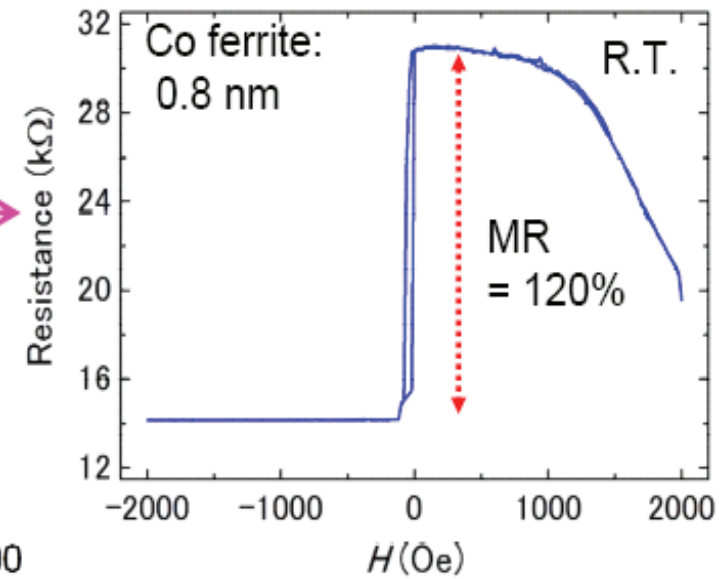
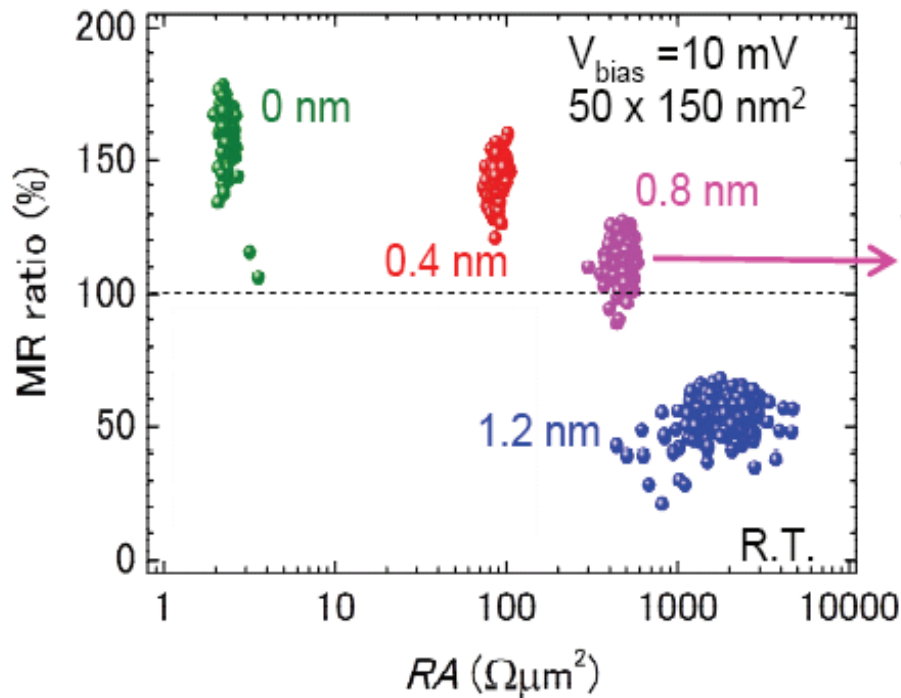
Stack: Sub/Ta5/UL50/Ta5/NiFe5/IrMn8/CoFe2/Ru8/CoFeB3/MgO/CoFeB30/Ta5/Ru15 (nm)

Tohoku Univ. and Hitachi Ltd.

MgO RA MR Ratio are Highly Sensitive to Interface Material and Structure in Atomic Level

Top electrode
Co ₆₀ Fe ₂₀ B ₂₀ (3 nm)
Co ferrite (x nm)
MgO (1.2 nm)
Co ₆₀ Fe ₂₀ B ₂₀ (3 nm)
Ru (0.9 nm)
Co ₇₀ Fe ₃₀ (2.5 nm)
IrMn (7 nm)
Ru (5 nm)
Bottom electrode
Thermally oxide Si wafer

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



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

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