THIC Inc. The Premier Advanced Recording Technology Forum

Achieving 10 Terabytes/Cartridge by 2011

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Market Trends

The "New Storage Drivers"

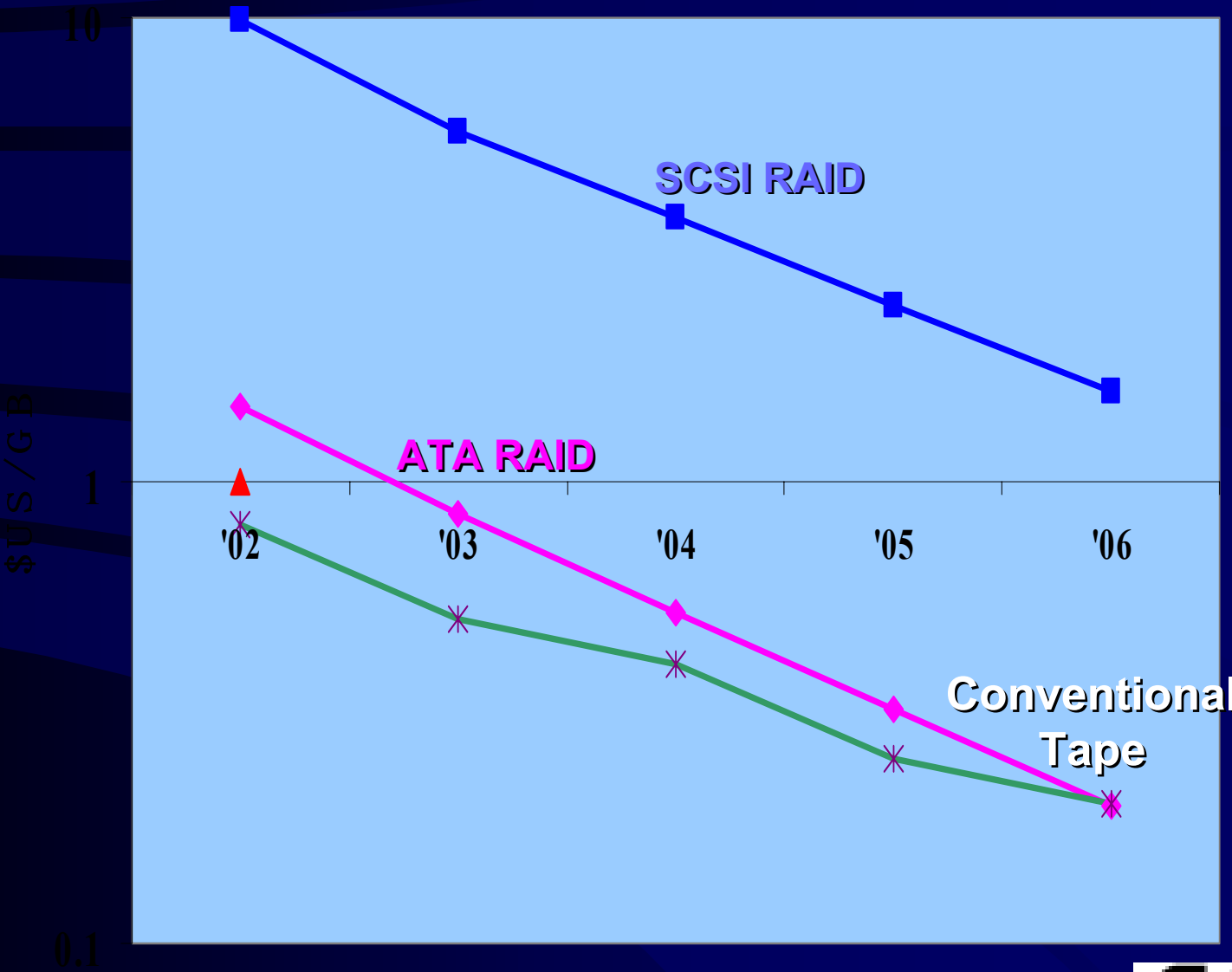
- Continued Strong Growth Potential for Tape:
  - Disk Capacities Shipped
  - More Data Captured Electronically
  - Explosive growth of Digital Content
  - Expanded Needs for Archiving and Data Protection

Storage Trends

- Disk Capacities Continue to Grow
  - Reduced $/GB
  - Cost of Tape Media Approaching Disk Drive
  - Low-Cost ATA Raid Threatens Tape in key Markets
- Future Tape Capacity and $/GB Trend needs to Change to Remain Competitive

Tape vs. Disk – Current Trend

Source HDD cost data: IDC



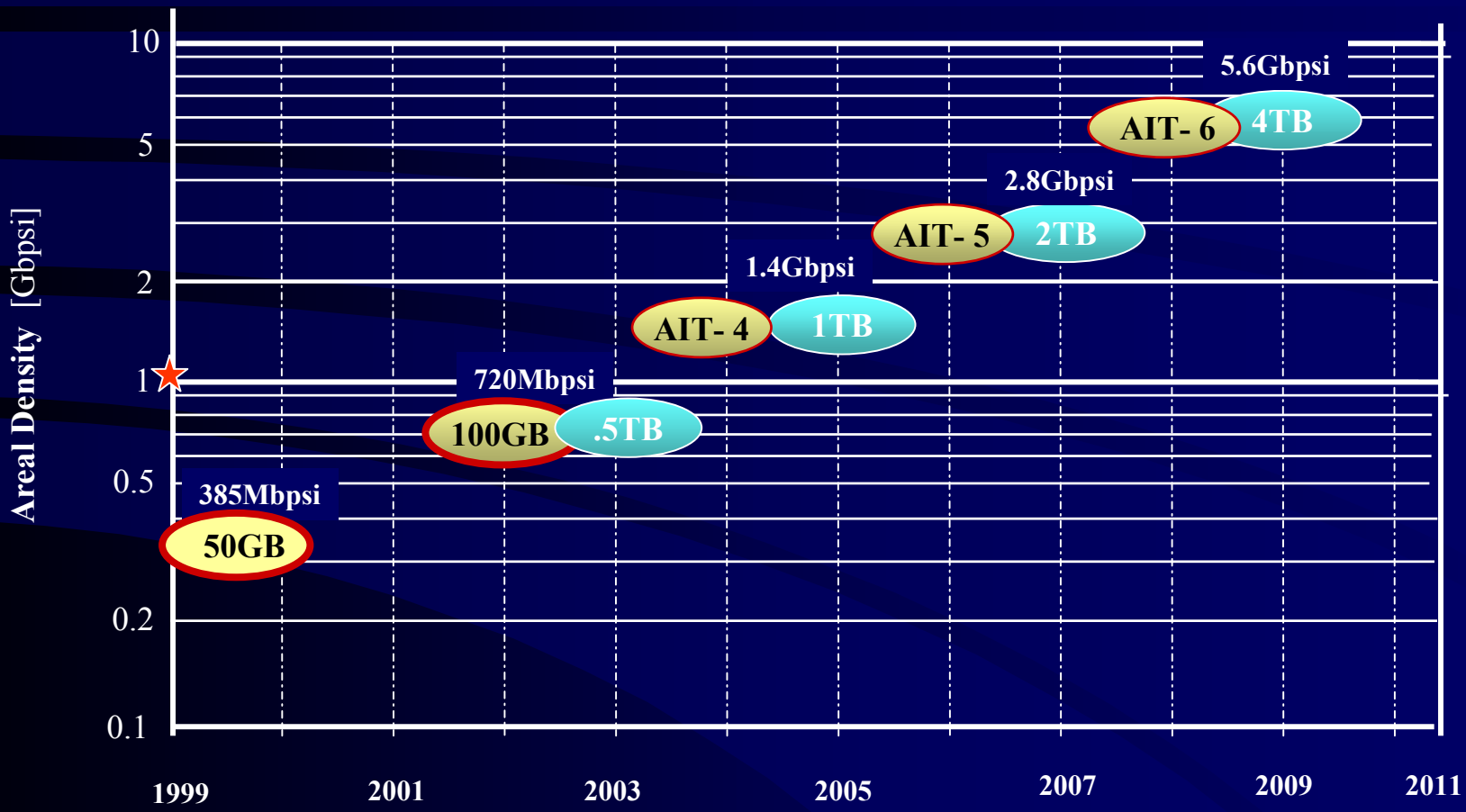
Achieving 10 Terabytes per Cartridge

- What is Sony Approach?
  - Much Higher Areal Density
  - More Tape (Single vs. Dual Reel)
  - New Component Technologies
    - Heads
    - Media
    - Encoding
    - Mechanics

Achieving 10 Terabytes per Cartridge

- What is Sony Approach?
  - Leverage Sony Areal Recording Density Using MR Technology and new Media Form-Factor:
    - If Media were Longer and Wider (eg. LTO/DLT - style) then other Capacity Points could be achievable over Current AIT Roadmaps at Constant Areal Density (@ 5X Capacity Points)

Capacity Trends @ Constant Areal Density



SONY

S-AIT Roadmap

SAIT-1

0.5 TB
30 MBps

SAIT-2

1 TB
60 MBps

SAIT-3

2 TB
120 MBps

SAIT-4

4 TB
240 MBps

Tape	A-ME	A-ME	A-ME	A-ME
Head	Laminated+	Laminated++	MR	GMR
Coding	TCPR	TCPR	Turbo	Turbo
Track Pitch (um)	5.50	3.67	2.75	1.83
Drum Speed (rpm)	5000	6667	8889	10000

MR Heads for Helical Scan Tape

- Early Research Confirmed Feasibility (1996)
  - 0.5μm wavelength
  - 11μm track width
  - 100KHz Resolution Bandwidth
  - AME Media, Azimuth Recording at 10m/s
  - C/N 52dB

MR Heads for Helical Scan Tape

- Early Feasibility Research (1996 Cont'd)
  - Azimuth Loss and Off-Track Profile Acceptable
  - Thermal Asperity Effect on MR Minimized
    - Optimized Low Pass Filter with MR Head on Drum
  - Static Charge Build-up on Head Minimize through AME Conductive Layer

MR Heads for Helical Scan Tape

- Further Research (1999)Demonstrated MR Head Application at Higher Density
  - Writing Track Width 3um
  - Minimum Wavelength .25um
  - Velocity 10m/s

--> Demonstrated 1Gbit/in^2 using Spherical Head with Sandwiched MR

First Application of MR-AME to Helical-Scan Recording

TR-IP7

Spring 2001

Higher-Density Helical-Scan Recording

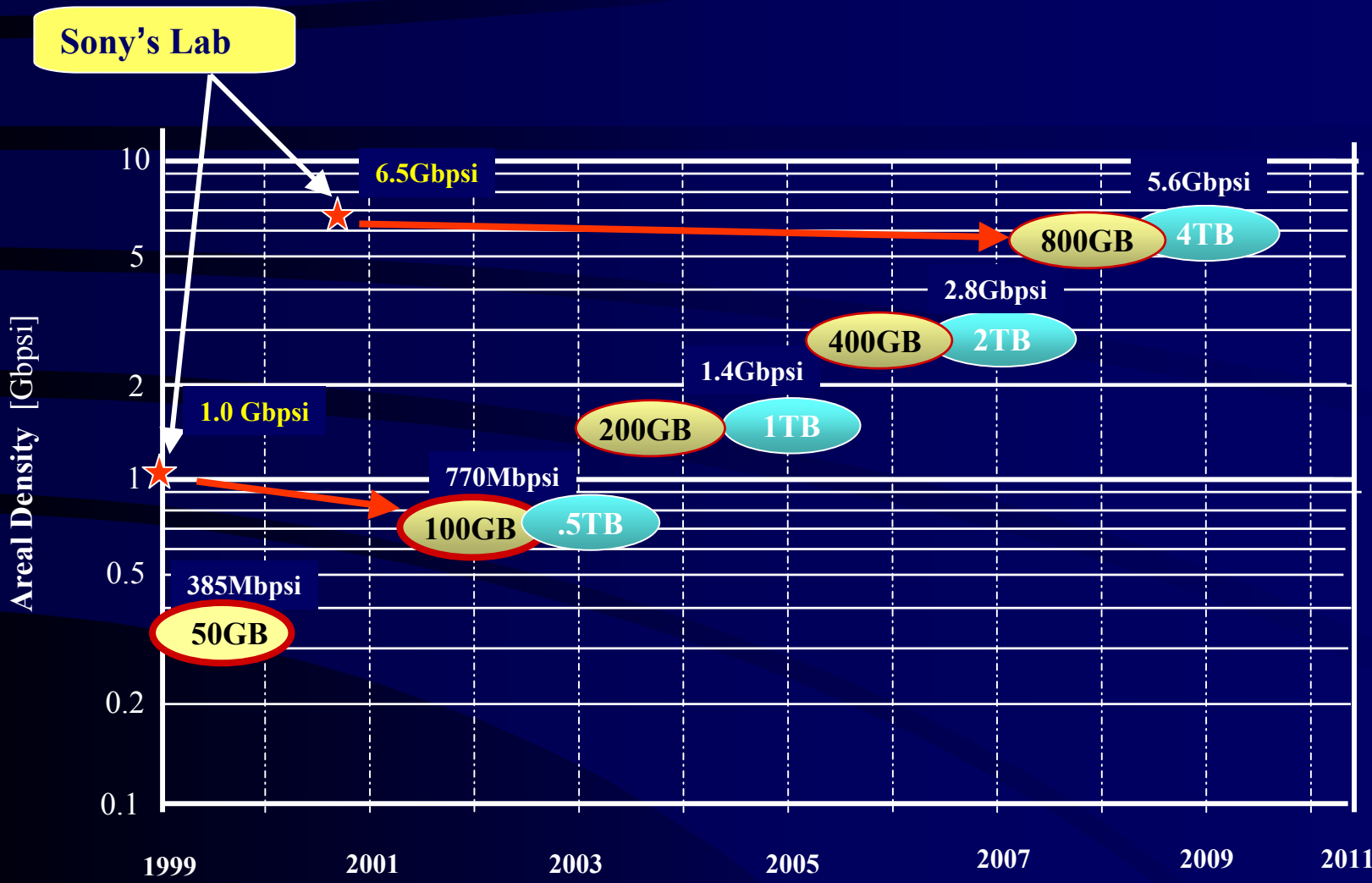
- Additional Research & Demonstration (2000) Confirmed Feasibility of using GMR Heads to achieve:
  - 6.5Gbit/in^2
    - 32K TPI Track Density
    - 203 KBPI Linear Bit Density
- Low-Noise AME with 33 nm Magnetization Layer

Comparison of Inductive vs. AMR vs. GMR

(Current Roadmaps)

	Inductive	AMR	GMR
Areal Density (Gbit/ in^2)	0.7	1.6	6.5
Track density (KTPI)	4.6	9.3	31.8
SNR (db)	18	22	26
Capacity(GB), 8mm Cartridge	100	200	800
Capacity(GB), ½"Cartridge	500	1,000	4,000

Areal Density & Capacity Trends



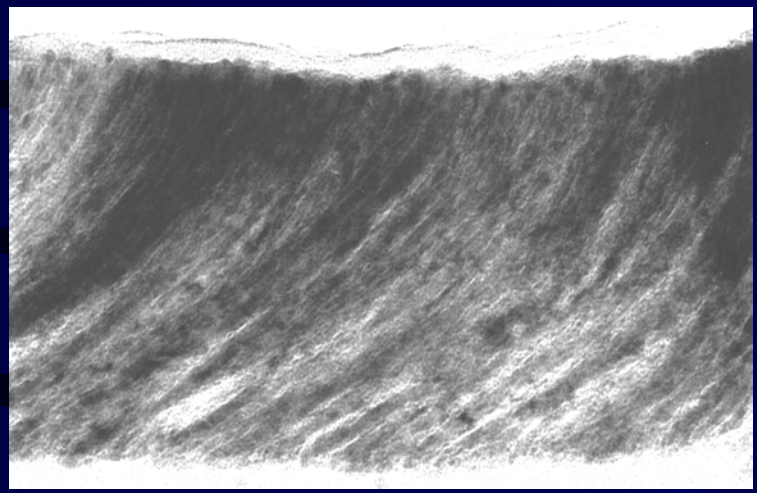
Ultra High-Density Helical-Scan Recording

- Additional Research & Demonstration (2001) Confirmed Feasibility of using Improved GMR Heads to achieve:
  - 16.4GBit/ in^2
  - 56.4 KTPI Track Density
    - 290 KBPI Linear Bit Density
- Low-Noise AME Media using 28 nm Magnetization Layer

Comparison of GMR-1,-2 Test Results

	GMR-1	GMR-2
Head Width	0.8 µm	0.45 µm
Dist. Between Shields	0.18 µm	0.12 µm
MR Height	0.8 µm	0.5 µm
Write Head	MIG	MIG
Relative Tape Velocity	3.6 m/s	3.6 ms
Mrt of Tape	10.0 ma	6.2 ma
Magnetic Layer	33 nm	28 nm
PW50	0.24 um	0.19um
SNR	26 db	18 db
Track Density	31.8 KTPI	56.4 KTPI
Linear Density (8-10 Coding)	203 KBPI	290 KBPI
Areal Recording Density	6.5 Gb/in^2	16.4 Gb/ in^2

High-Output AME Media and GMR Head

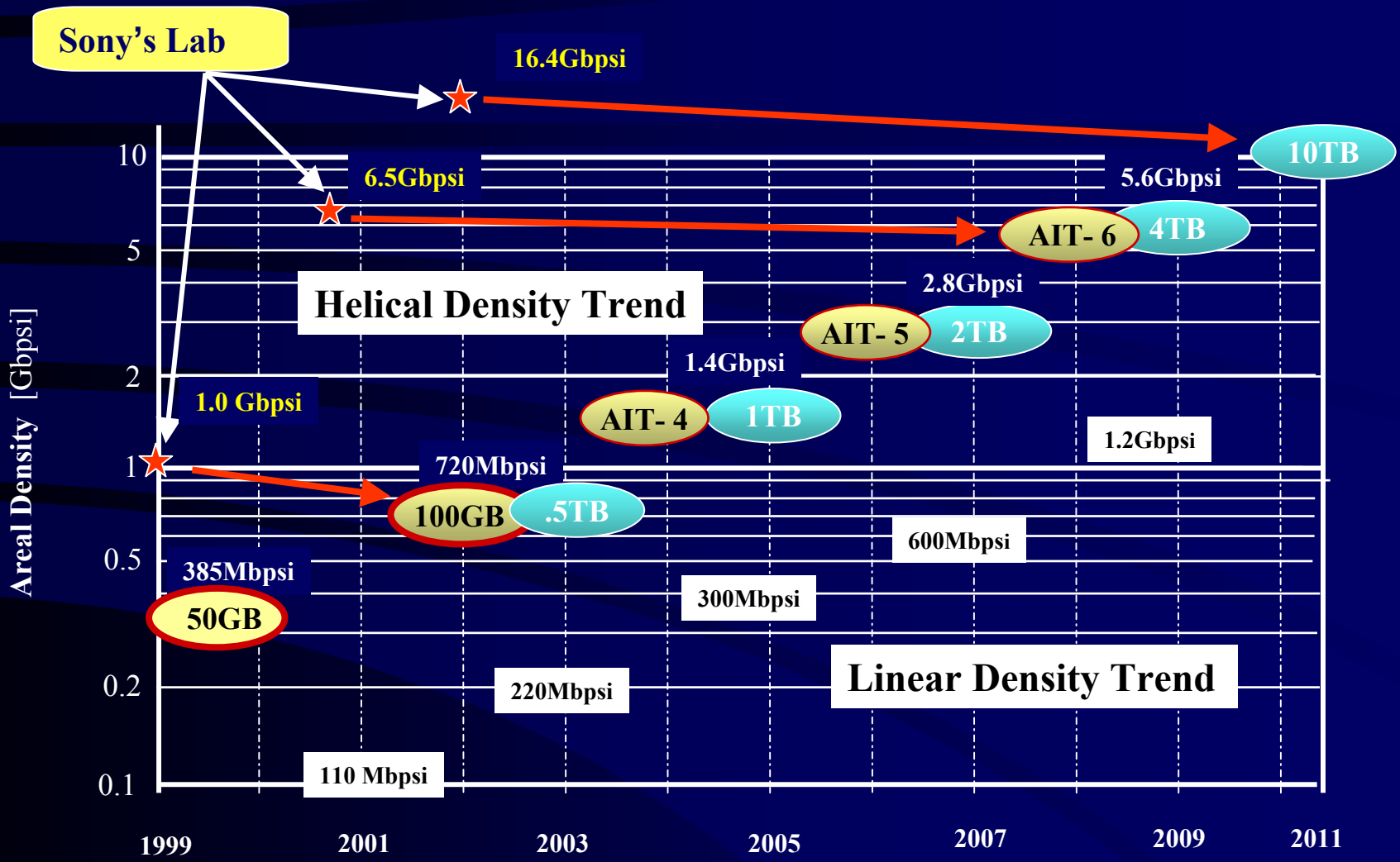


185nm Today

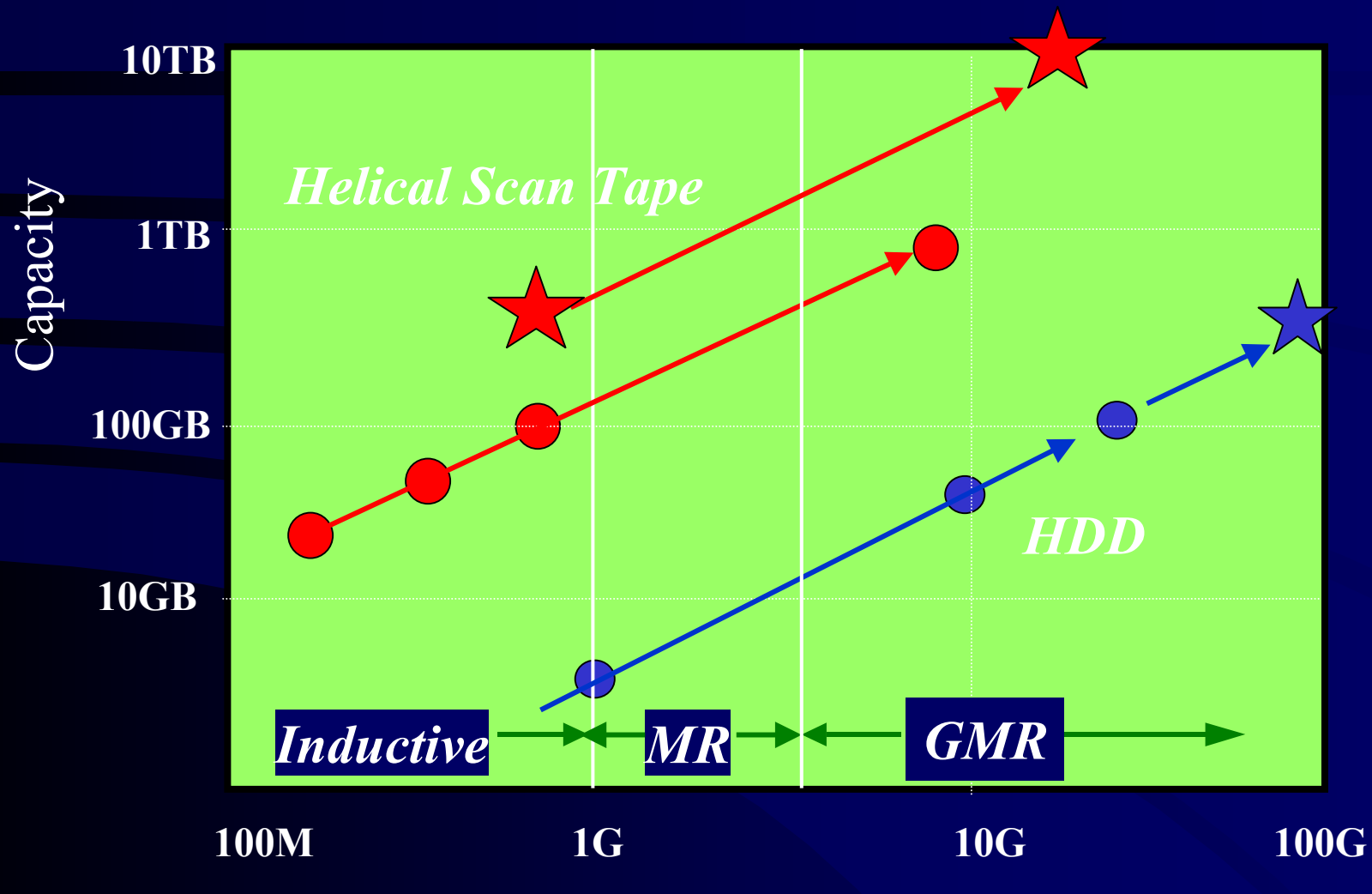
33 → 28 nm

Metal Evaporated Tape	GMR-1 ------→ GMR-2
Magnetic Layer	Cobalt-Cobalt Oxide
Thickness of Magnetic Layer (t)	33nm ------→ 28nm
GMR Head	
Type	Shield-Spin Valve GMR Head
Head Width	0.8 μ m ------→ .45 μ m
Other	
Signal-to-Noise Ratio	26dB ------→ 18dB

Areal Density & Capacity Trends

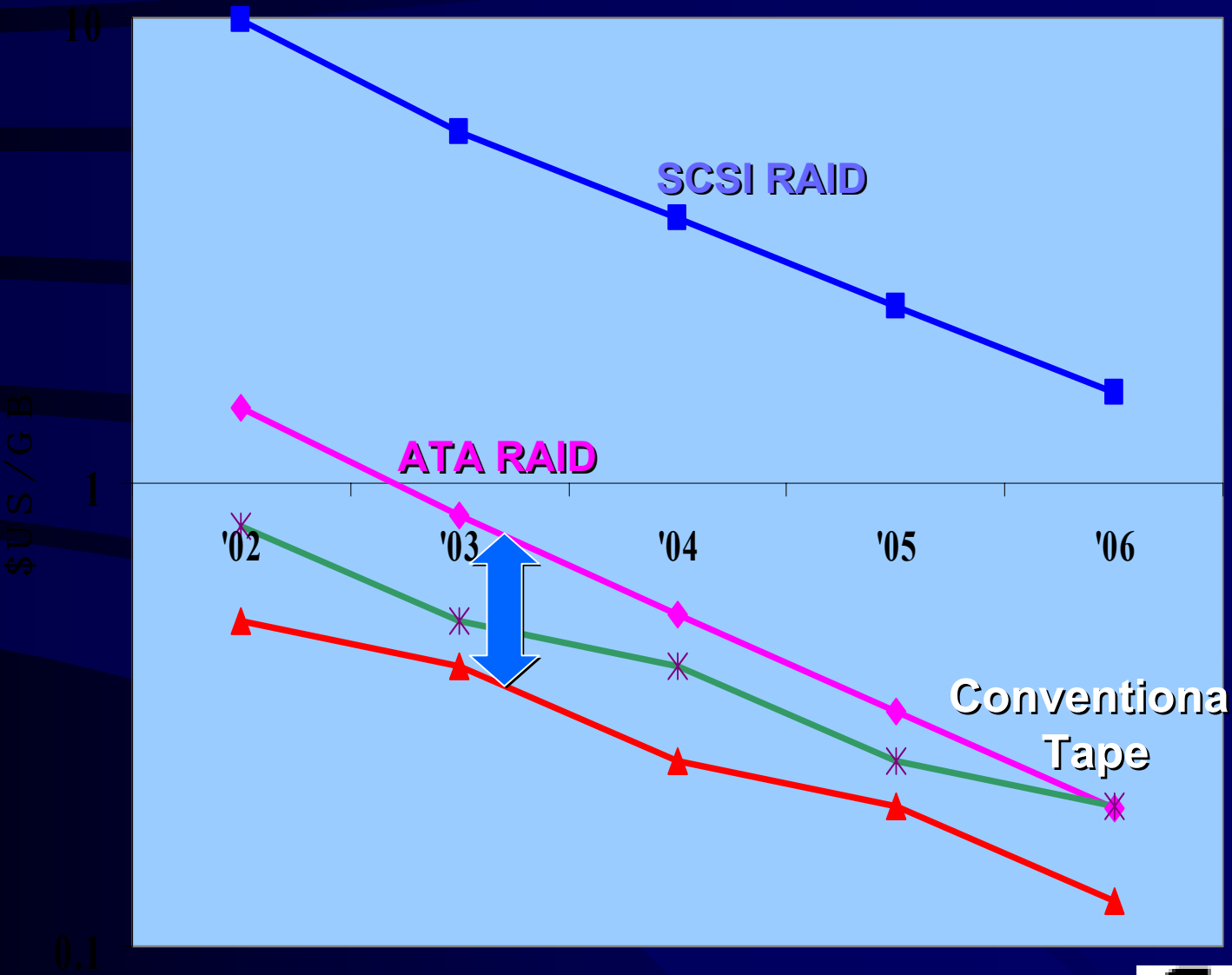


Tape/Disk Technology Trends



Re-establishing Tape's Advantage

Source HDD cost data: IDC



Summary

- Advanced Development and Application of New GMR Head Technology has Demonstrated 16.5 Gb/ in^2. Areal Density
- Application of MR/GMR Head Technology with A-ME will Lead to:
  - AIT Technology Roadmap of up to 1TByte per 8mm Cassette
  - "S-AIT" Technology Roadmap extending to 10 TBytes per Cartridge

Conclusions

- Tape is Vital to the Future of Storage
  - Increased Per Cartridge Capacity
  - Scalability through Automation
  - Removeability & Archivability
- Tape can Continue to Maintain is Cost/GB Advantage over Disk
  - New Technology Demonstrations and Roadmaps
  - Magnetic Recording Limitations not yet on Horizon

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Thank You!

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