The Ultra Small HDD for the Mobile Applications

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Outline

- **Target consumer for ultra-small HDD and the comparison with the flash memories**

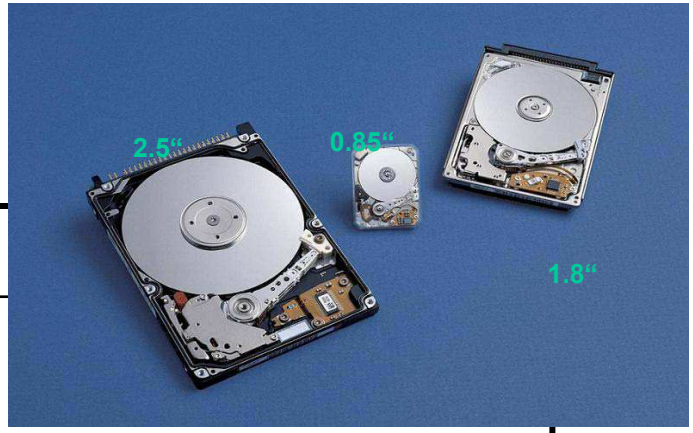
- **Mechanical feature of 0.85” HDD**

  - Shock durability –

- **To keep the data capacity growth per year**

  - New perpendicular magnetic recording -

Today's HDD Capacity & Target Market



Size	Data Capacity	Use
3.5"	200GB-600GB (150-180GB/pl.)	Desktop PCs Servers HDD video recorders
2.5"	40GB-200GB (80-100GB/pl.)	Notebook PCs Small size network servers Car applications
1.8"	20-80GB (40GB/pl.)	Mobile PCs MP3 players Portable video cameras & players
0.85" -1"	**2-10GB**	Cellular phones MP3 players

Size and Other Specifications of Small Memories

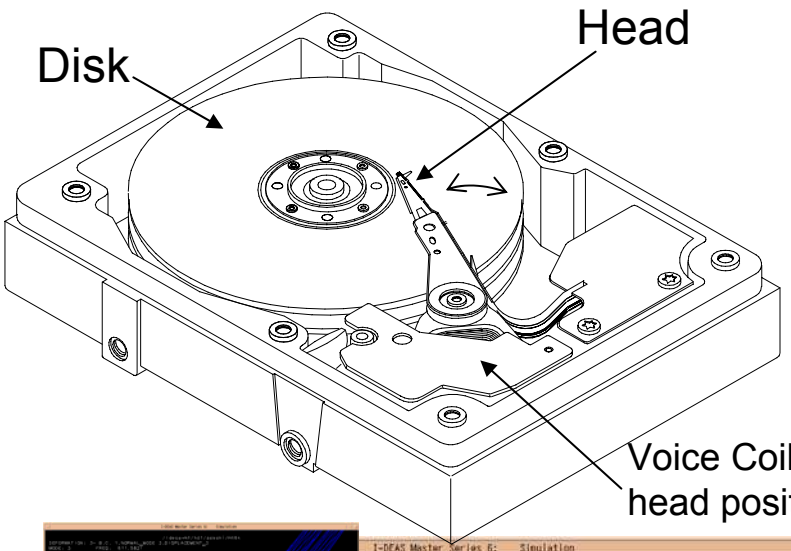
1.0” HDD size is the same as Compact Flash.

0.85” HDD size is the same as SD card.

		Compact Flash	SD card	1.8" HDD	1.0" HDD	0.85" HDD
Size	Width	36.4 mm	24 mm	54 mm	36.4 mm	24 mm
	Length	42.8 mm	32 mm	78.5 mm	42.8 mm	32 mm
	Height	3.3 mm	2.1 mm	5 / 8mm	5 mm	5 mm
Shock Durability	On data access	2000 G	1000 G	500 G	200 G	1000 G
	Off data access	2000 G	1000 G	1500 G	2000 G	2000 G
Temperature	On data access	0 ~ 60 °C	0 ~ 55 °C	0 ~ 60 °C	0 ~ 70 °C	0 ~ 70 °C
	Off data access	-25 ~ 85 °C	-20 ~ 65 °C		-40 ~ 80 °C	-40 ~ 80 °C
Altitude	On data access	24000 m		3000 m	3000 m	3000 m
Input Voltage		3.3 V	2.7□3.6 V	3.3 V / 5 V	3.3 V / 5 V	3.0 V
Transfer Rate		16.6MB/sec	12.5MB/sec	100MB/sec	10MB/sec	12.5MB/sec

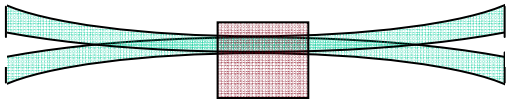
Mechanical Feature of 0.85” HDD

Hard Disk Drive (HDD) Structure

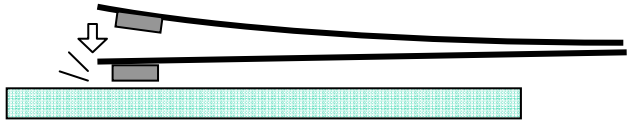


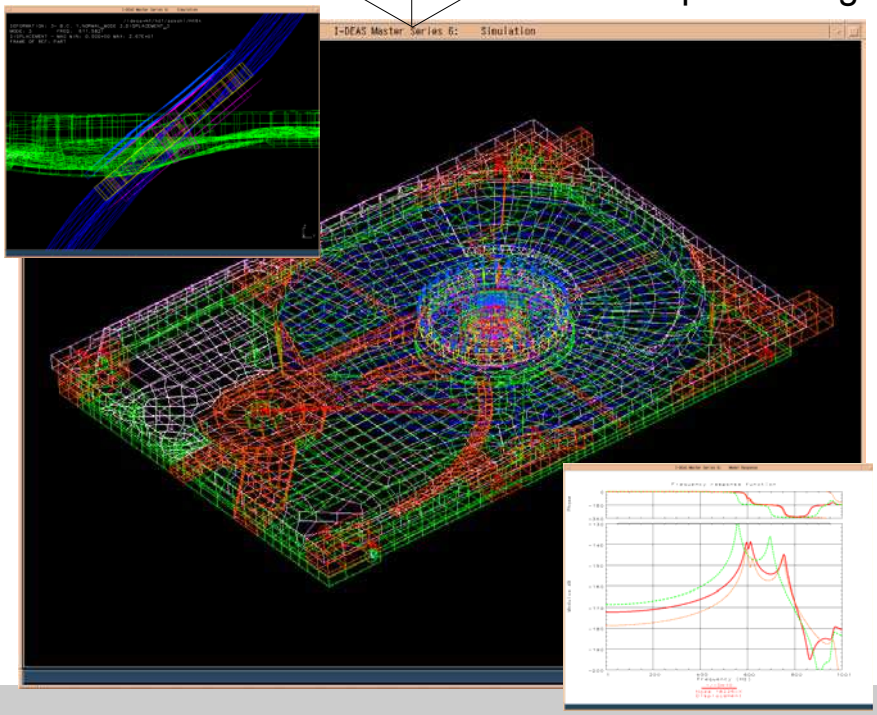
The sensitive parts of HDD with external shock

(1) Disk winding and rolling



(2) Head suspension hitting on disk



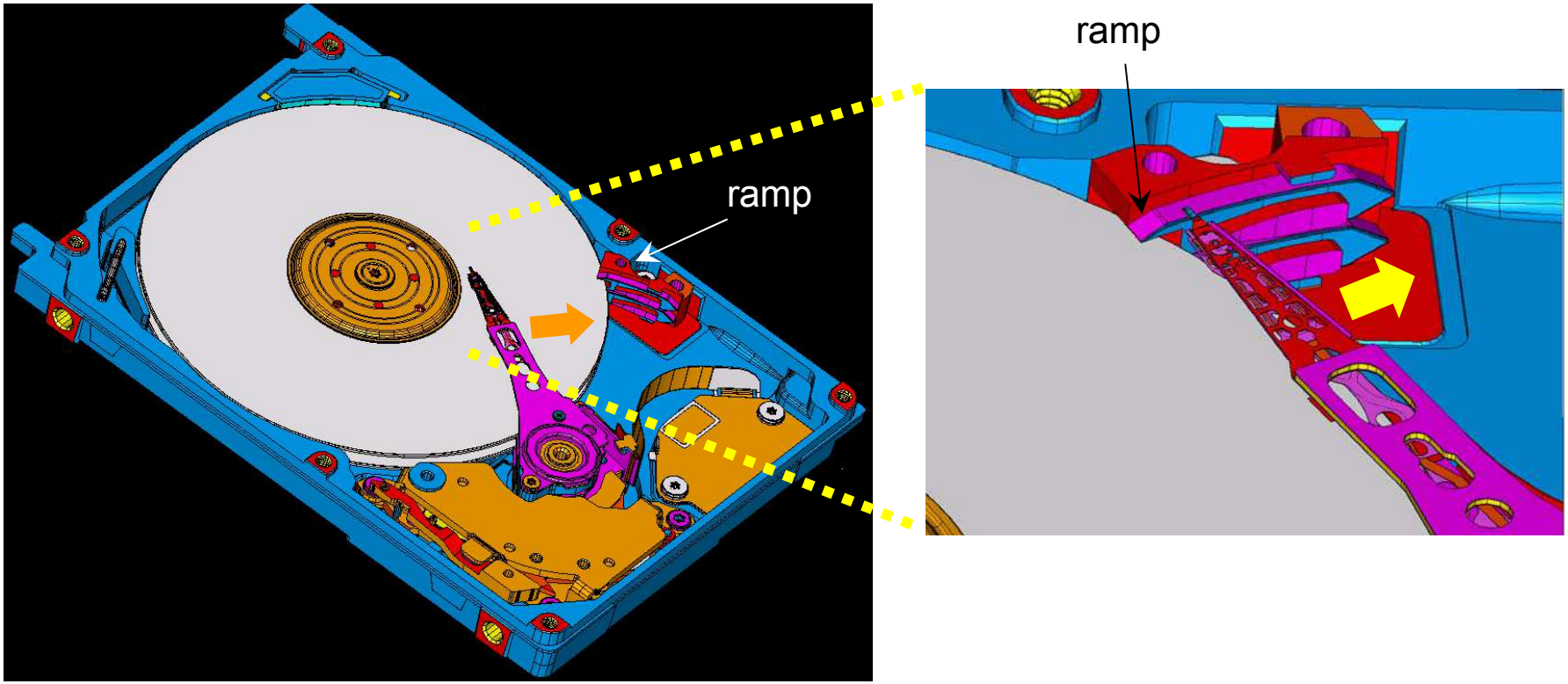


Example of HDD mechanical roll analysis by FEM simulation

Load/Unload System

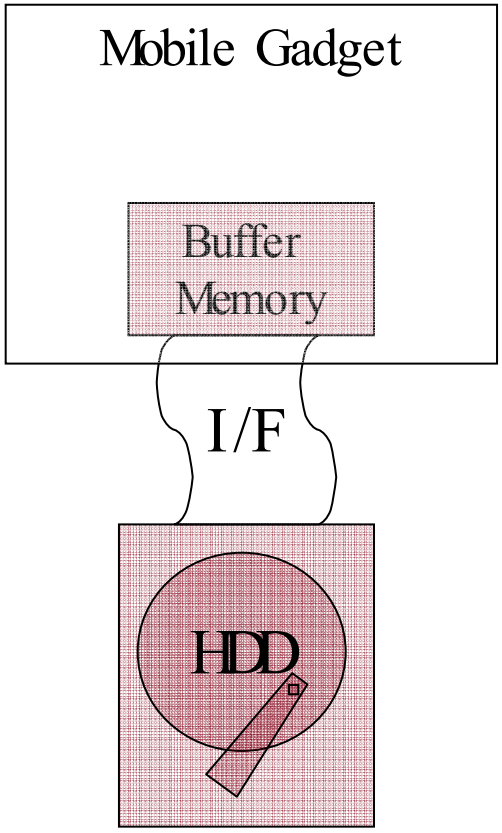
To avoid Head/Disk interaction by external shock, the heads frequently unload from the disk surface to the ramp potion while idling.

＝ There are no damage on head/disk interaction when the head escapes on the ramp. The shock durability while head unload state is higher than that while head on disk.



Data Access Frequency with Mobile System

Some of mobile gadget have large buffer memories to temporarily store the HDD data, which minimize both the electric power and the head access frequency on disk in HDD.



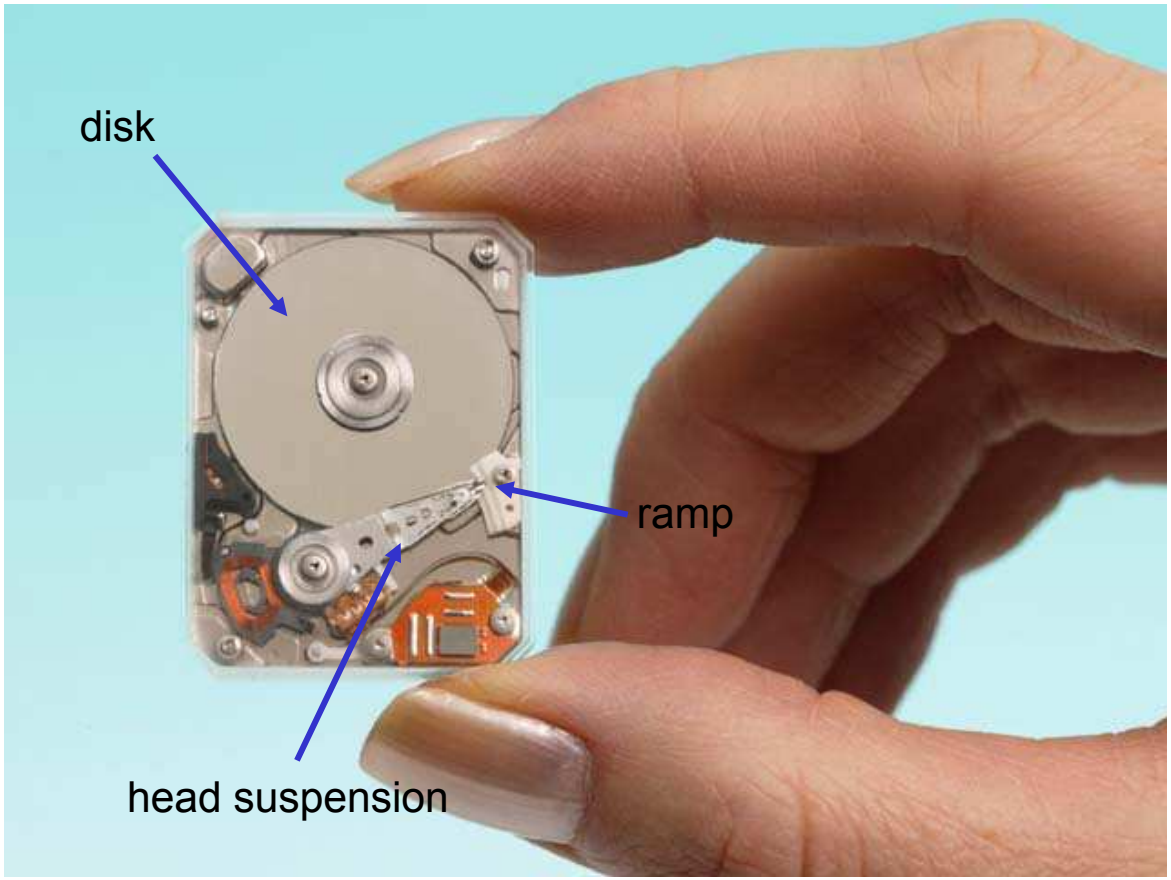
ex. MP3 Player

Data size (1 song)	4–6 Mbyte
Play time	4–5 minutes (250-300 sec)
Buffer Memory size	64 Mbyte
HDD Data Transfer Rate	12.5 Mbyte/sec
HDD Data Access Time	0.4-0.5 sec

During 1 song play-out, the read head has to be on disk for data readings for **only 0.3%** term of whole play-out time.

0.85” HDD Structure

Even in the ultra small 0.85” HDD, the basic structure is the same as the other large size HDD. JUST down-scaling!

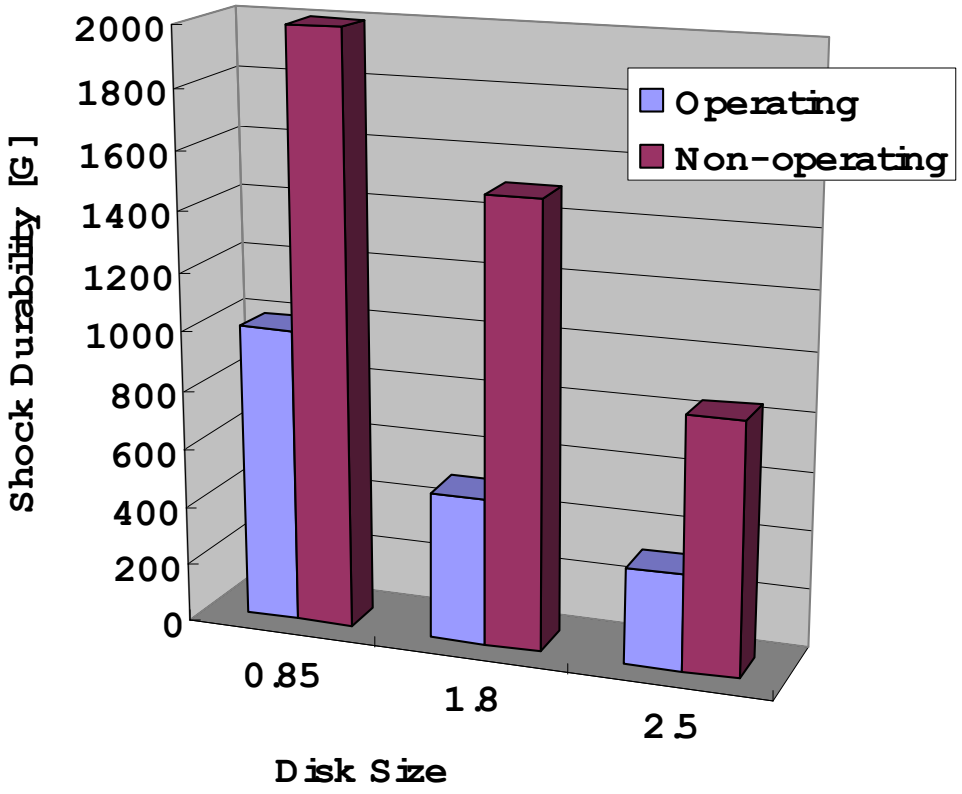


Shock Durability While Head Seeking

The smaller radius disks are easy to show the higher shock robustness because of its small rolling and light weight.

The shorter head suspension arm length also shows higher shock robustness.

Therefore small sized HDD could achieve better shock durability.



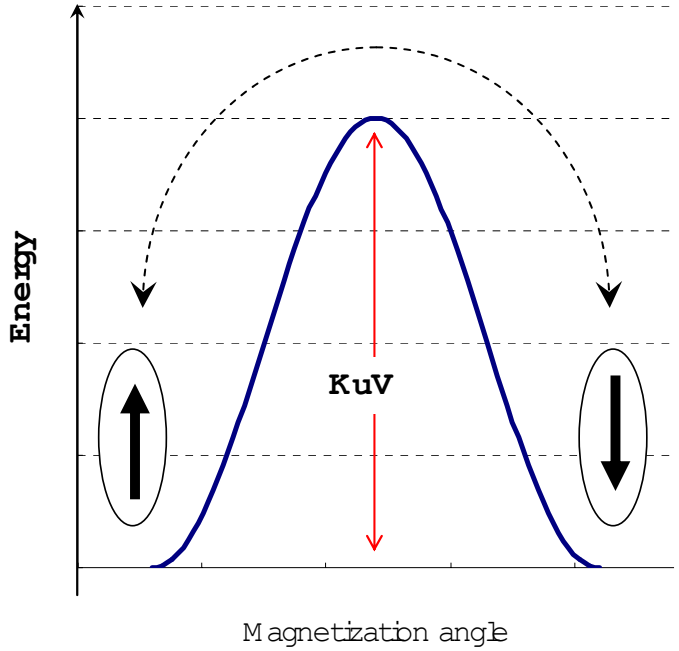
Short Summary

- **0.85” HDD was developed for the large data capacity storage device which has the compatible size with the SD card memories.**
- **The head Load/Unload system is applied for the higher shock durability mobile device.**
- **The 0.85” small radius disk and the short head suspension realize almost same shock durability specification as the Flash card memory.**

Keep Data Capacity Growth

What makes the areal density limit of the magnetic recording?

Thermal Magnetization Fluctuation



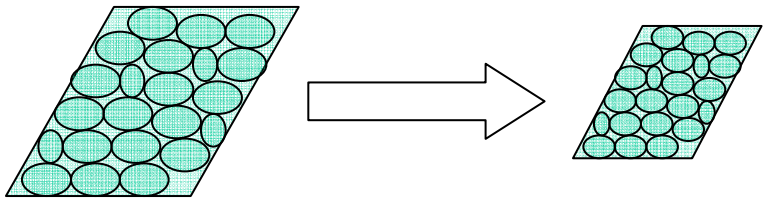
K_u : anisotropy coefficient
V : volume of particle
k : Boltzmann constant
T : temperature

If the thermal energy *"kT"* is larger than the magnetic anisotropy energy *"K_uV"*, the particle magnetization is always easy to flip and very unstable.

Based on previous many experimental results, *"K_uV/kT"* should be larger than 60 to keep the magnetization amplitude for 10 years.

$$K_uV/kT > 60$$

There are many magnetic particles in one data recorded bit to get fine S/N ratio



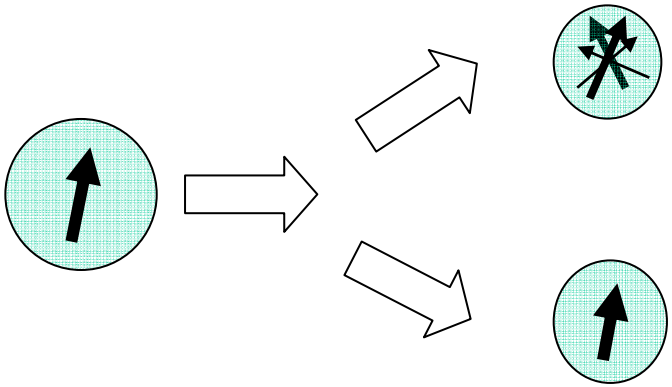
The larger data capacity

= Higher recorded density

= Smaller data bit size

= Smaller particle size

If K_uV/kT becomes close to 60, …



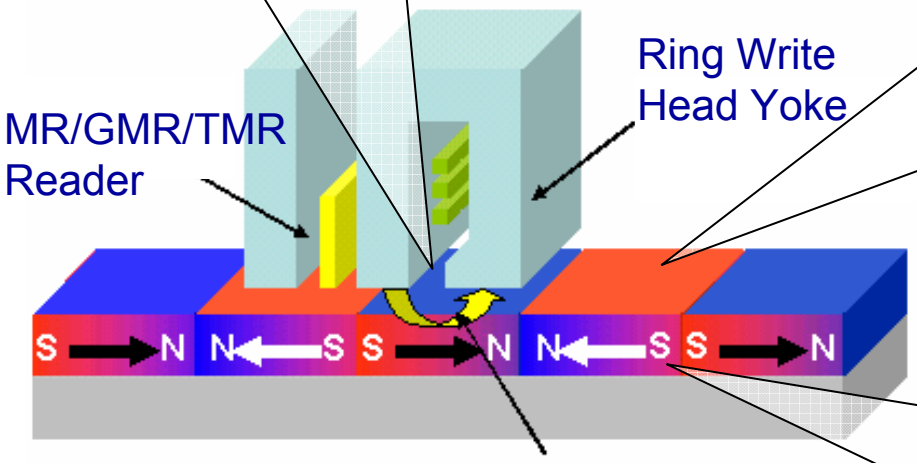
Smaller volume with same K_u,
= x unstable magnetization

Smaller volume with higher K_u,
= o stable magnetization,
x hard to re-write the information with write head

The write head ability would define the limit of K_u. Then minimum particle volume V will be limited to keep $K_uV/kT > 60$.

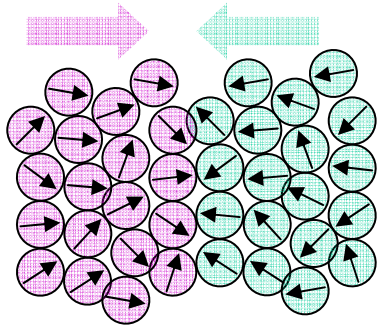
Longitudinal Recording System

Write Ability:
Maximum recording field near gap
=0.5 x head yoke magnetic flux density

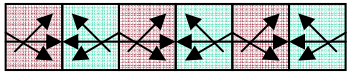


Medium particle orientation:

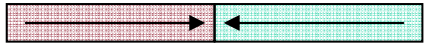
- **2D random in disk plane**
- **About 50 particles in one data bit to keep fine S/N ratio**



Higher linear density = thermally unstable



Lower linear density = thermally stable

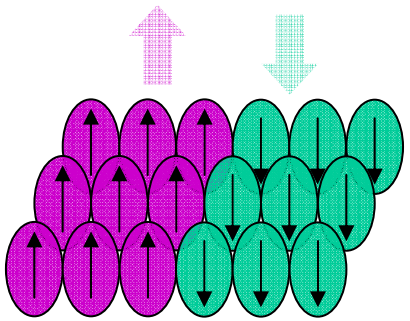


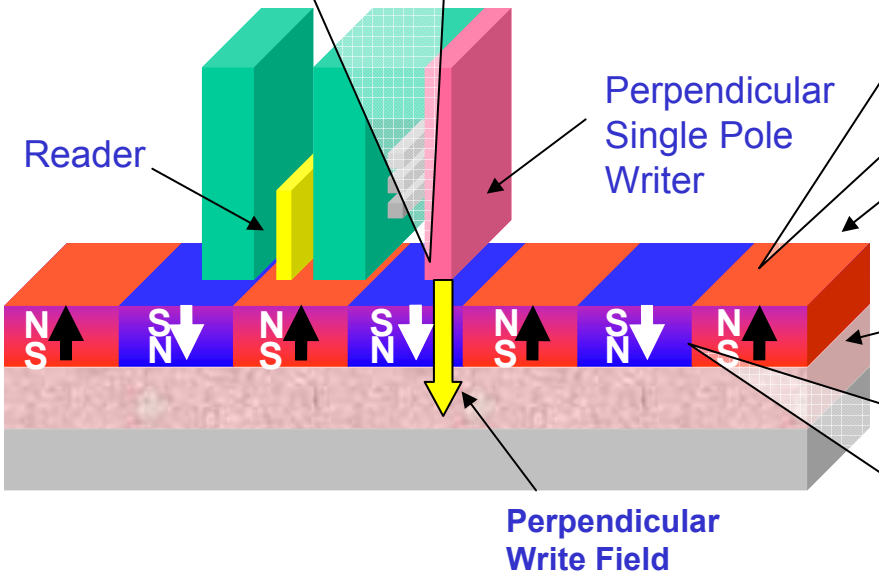
Perpendicular Recording System

Write Ability:
Maximum recording field near gap
=1.0 x head yoke magnetic flux density
= 2 times of LMR field limit

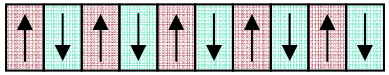
Medium particle orientation:

- **Single orientation perpendicular to disk plane**
- **About 30 particles in one data bit to keep fine S/N ratio**

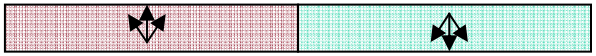




Higher linear density = thermally stable



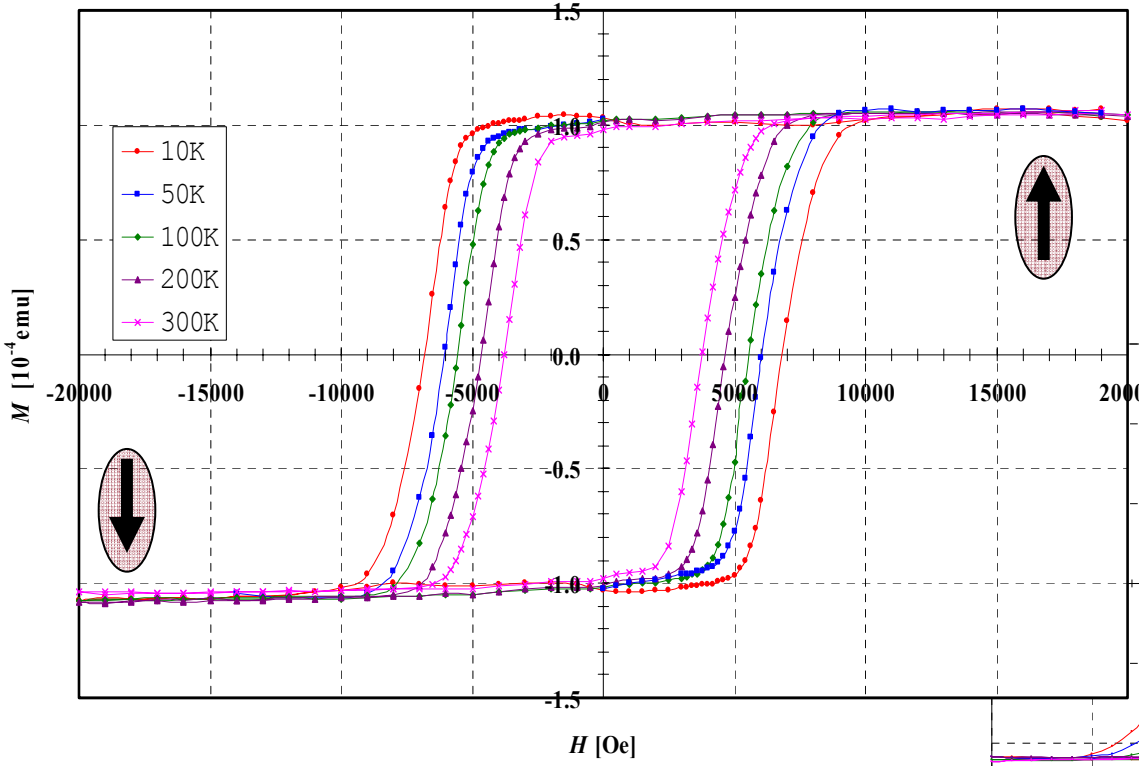
Lower linear density = thermally unstable



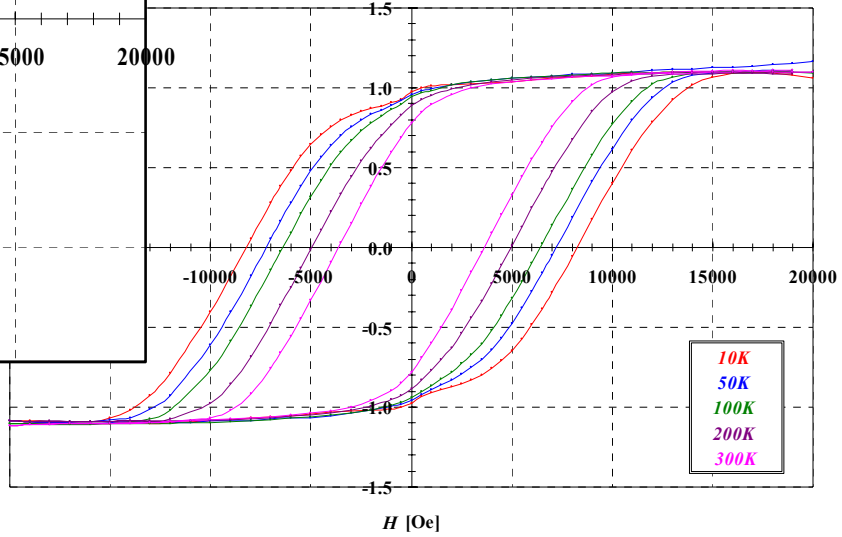
Key of Success for Perpendicular Recording HDD

Remanence of high Hn medium keeps good thermal stability under low density demagnetized field

Temperature dependence of M-H loop of CoPtCrO Media

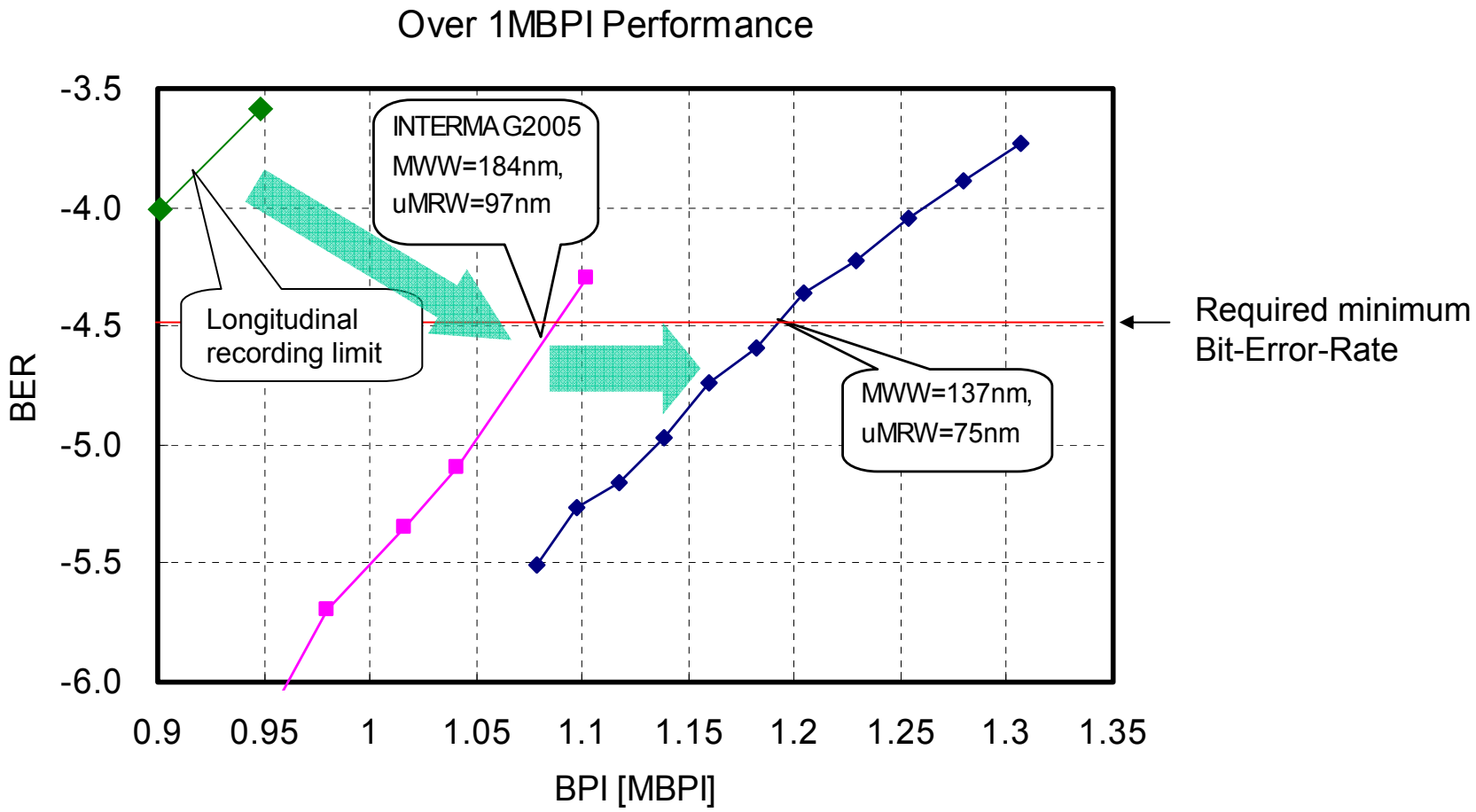


e.x. M-H loop of low squareness medium

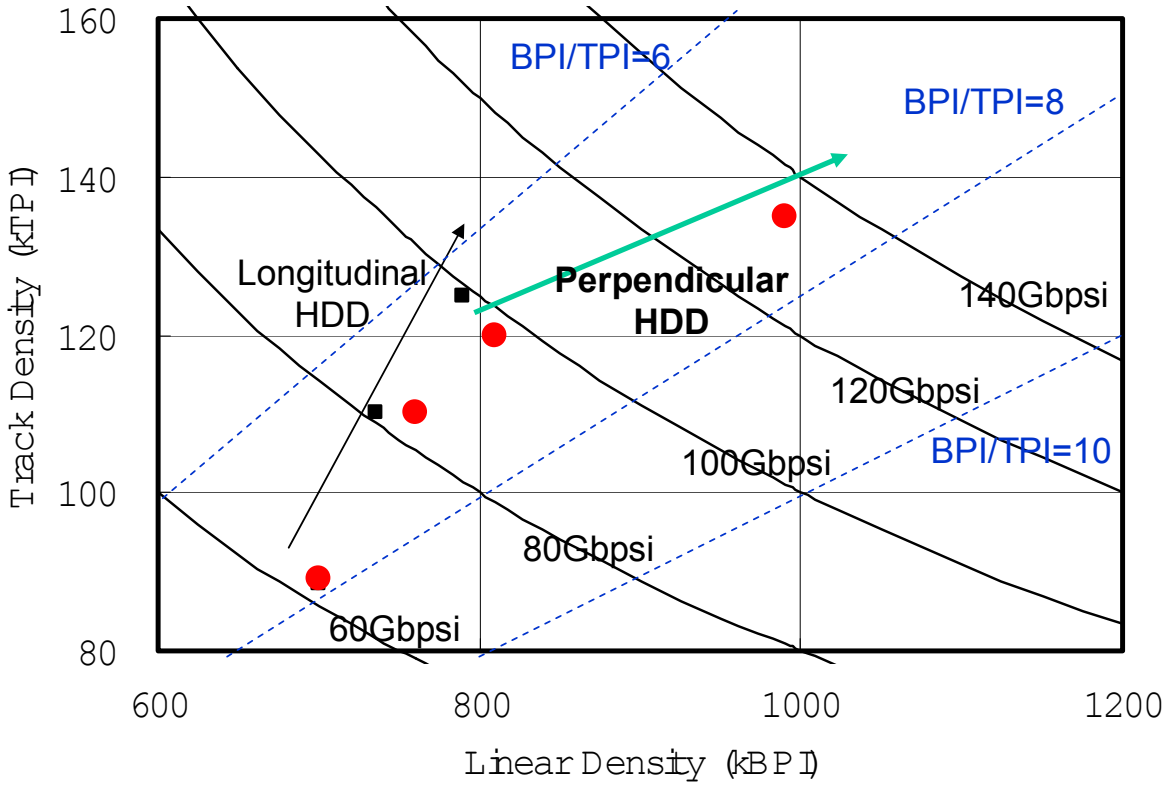


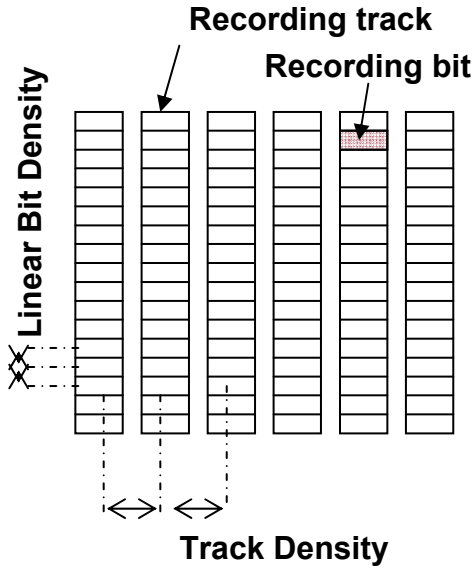
High Density Recording beyond □MBPI

1.2Mbit/inch (1200kbit/inch) linear density achieved with 137nm magnetic write track width head.



Toward Higher BPI





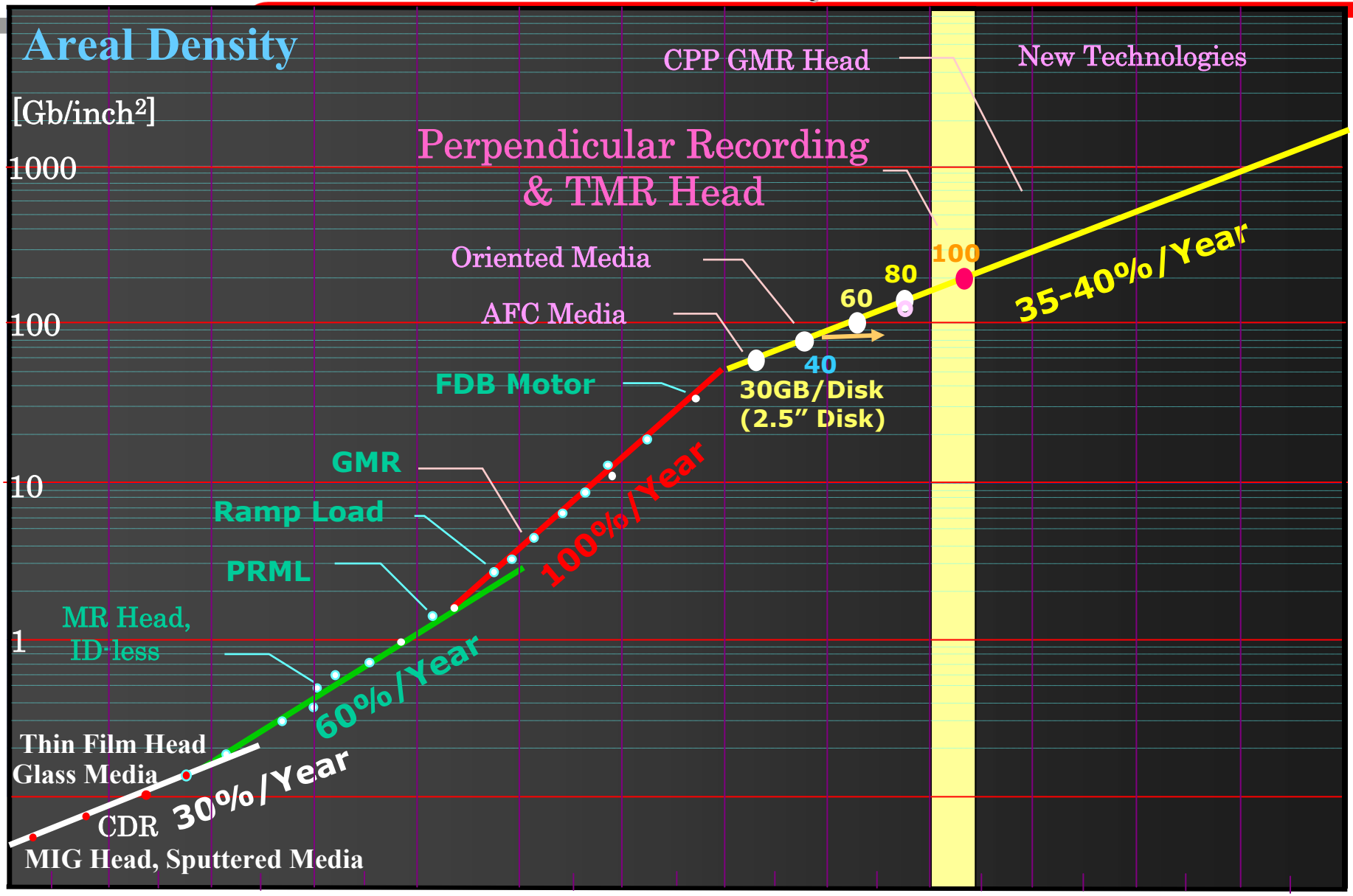
Perpendicular recording HDD tends to higher BPI/TPI ratio than previous longitudinal HDD, which means the perpendicular HDD makes higher data transfer rate more easily.

8GB / 10GB 0.85” HDD Basic Specification (Proto-type released in CES2006)

	4GB commertial product	8GB Proto-type	10GB Proto-type
Disk	1 platter	1 platter	1 platter
Head	2 heads	2 heads	2 heads
ArealDensity	84 Gbpsi	159 Gbpsi	198 Gbpsi
Track Density	113 kTPI	165 kTPI	165 kTPI
Linear Density	743 kBPI	960 kBPI	1195 kBPI
Recording System	Longitudinal	Perpendicular	Perpendicular
Density Increment	-	189%	236%

TOSHIBA

HDD Areal Density Trend



Summary

- **0.85” HDD was developed for the large data capacity storage device which has the compatible size with the SD card memories.**

- **To utilize the ramp load system & temporary buffer memories, 0.85 HDD shock durability is almost cleared about 2000G on end-user operating.**

- **Applying the perpendicular recording technology, 8/10GB proto type HDDs were realized. This technology will keep areal density growth over 35%/year in coming 5-10 years.**