Fundamental of HDD Technology (4)

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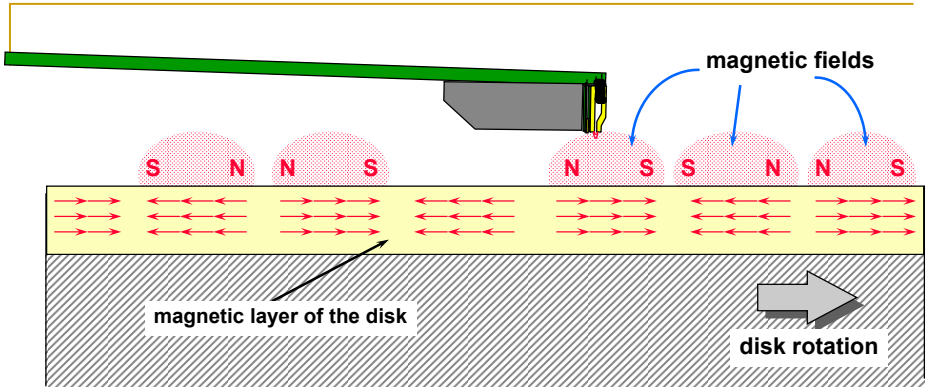
Outline

- Basic Read/Write Heads
- Flying Height
- Air Circulation and Air Filtration
- Head Crashes
- How to handle HDDs
- Read/Write Head Technologies
  - Ferrite Head
  - Thin Film Head

Basic Read/Write Heads

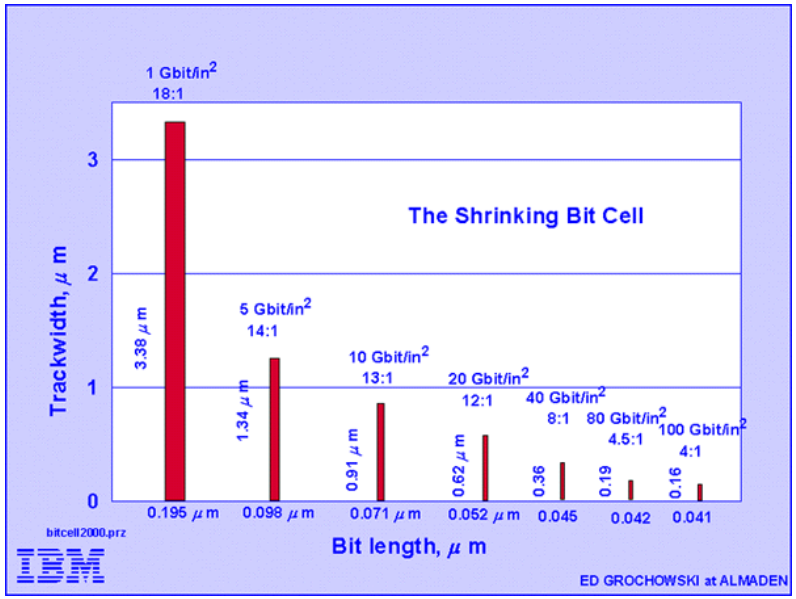
- Converting bits to magnetic pulses, storing them on the platter, and then reversing the process to read data back.
- New head technologies are often the triggering point to increasing the speed and size of HDDs.
- Old heads (ferrite, metal-in-gap and thin film) work by making use of the two main principles of electromagnetic force.
  - Applying an electrical current through a coil produces a magnetic field ⇒ Used to write data into the disk
  - Applying a magnetic field to a coil will cause an electrical current to flow ⇒ Used to read data back from the disk



- After the disk has been written to, it has billions of tiny little magnets polarized on it
- The little magnets are decoded as the data written to disk
- Future technology will include Perpendicular Recording

- Newer heads (MR and GMR)
  - Don't use the induced current in the coil to read back the information
  - Use the principle of magnetoresistance ⇒ certain materials change their resistance when subjected to different magnetic fields.
- High areal density ⇒ the tight packing of data bits ⇒ make sure that the magnetic fields don't interfere with one another.
  - The stored fields are very small and very weak.
  - The read/write heads must be faster and more sensitive so they can read the weaker fields.

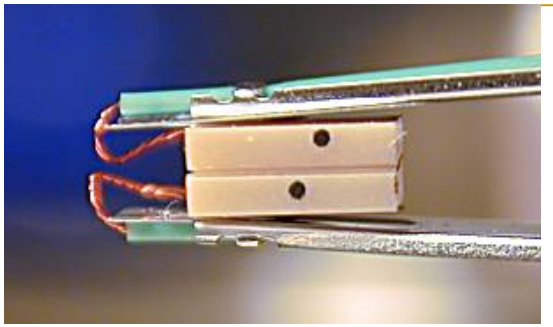
- This is the reason why MR and GMR heads have taken over the market.
  - More sensitive
  - Can be made very small so as not read adjacent tracks on the disk.
- Practically, only one head can read from or write to the hard disk at a given time.



Floating Height / Flying Height / Head Gap

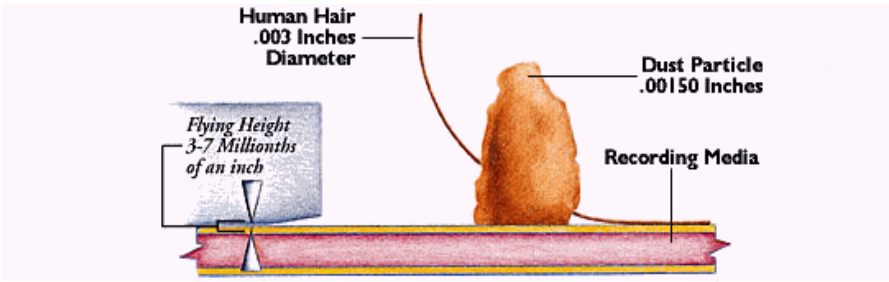
- Because of the high speed that the HDD spins, modern drive heads float over the surface of the disk and do all of their work without ever physically touching the platters.
- The amount of space between the heads and the platters is called the **flying height** or the head gap.
  - Some refer to the heads as riding on an "**air bearing**"

- The read/write head assemblies are spring-loaded, which causes the sliders to press against the platters when the disk is stationary.
- When the disk spins at an operating speed, the high speed causes air to flow under the sliders and lift them off the surface of the disk.
  - Same principle of lift that operates on aircraft wings and enables them to fly
- Due to the very small distance from the heads to the platters, the hard disk is assembled in a **clean room**.



- A pair of mated head sliders with their platter removed.
- You can see that the tension of the head arms has caused them to press against each other.

- Inside HDD, air is required for the heads to function.
  - Air exchange is permitted between the outside and inside of the drive to allow the drive to adjust to changes in air pressure.
  - A special "breather" filter is installed to prevent foreign matter from contaminating the drive.

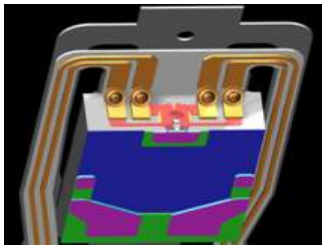


- Increasing areal density ⇒ Weaker magnetic fields must be used in storing data on the disks.
- The heads must ride closer and closer to the platter surface to pick up the weaker signals.
  - Also require other quality improvements to the drive to make sure that there is no chance of a **head crash**.

- Each time the floating height is decreased, the mechanical aspects of the disk must be adjusted to make sure that:
  - The platters are flatter
  - The alignment of the platter assembly and the read/write heads is perfect
  - No dust or dirt on the surface of the platters.
- Vibration and shock become more of a concern and must be compensate for.
- Newer heads (e.g. GMR) are preferred because they allow a higher flying height than older and less sensitive heads.

Facts – Heads

- In 1974, the head flying height was equivalent to a Boeing 747 airliner flying at 15 cm above the ground
  - In 2004, the 747 has to fly at **0.05 cm**
- The load on the slider is equivalent to 100,000 passengers
- The speed of the disk under the head is up to 92 km per hour for a 7200 RPM drive
- The head can survive repeated lateral accelerations of 1000 Gs and vertical accelerations of 300 Gs – humans black out at 9 Gs
- The 747 is designed for 30,000 take offs and landings, the head 100,000

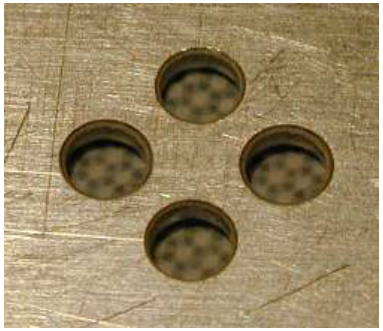


Air Circulation and Air Filtration

- Air is an essential component for proper drive operation.
- Regular hard disks aren't totally sealed from the outside air, but they definitely are separated from it, in order to ensure that the dirt and dust of the outside air is kept away from the delicate platters and heads of the drive.
  - If foreign matter were to get onto the platters ⇒ head crash
- In general, hard disks aren't sealed, because they have to be able to pass air between the inside of the drive and the outside, in order to equalize any air pressure differential that may exist between the two environments.

- This allows the disk to maintain proper equilibrium when the weather changes, or the drive is moved to a different altitude; if pressure is not balanced the drive might not perform properly and damage could even result.
- You can actually see the small *breather holes* in the cases of many drives, placed there for this purpose.
- Of course just putting a hole in the case would cause contamination of the drive, so the holes are covered with a *breather filter* which lets air pass through slowly but not dirt or dust.
- These filters are placed permanently and do not need to be serviced or replaced.

- Hard disks also have an internal air flow within their sealed chambers (caused by the rotation of the platters--there is no fan inside a hard disk).
- This air flow is used to continuously filter the air within the disk assembly.
- Despite building the hard disks in ultra-clean facilities and taking other precautions during manufacturing, a small recirculating filter is built into the drive itself as an added security measure.
- This filter is designed to work on the air that flows within the hard disk assembly, catching any minute bits of debris that might somehow make it inside.
- This reduces the chances that such dirt will end up on the disk platters.
- Like the breather filter, the recirculating filter is not changeable, nor does it need to be.



Closeup shot of the breather holes in the top of a hard disk case. Part of the Breather filter can be seen just under the holes.

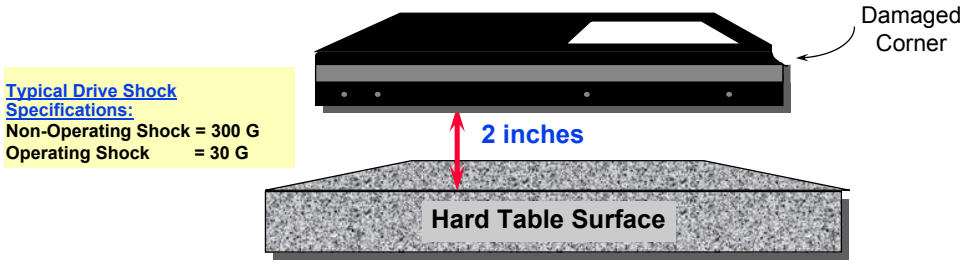
A recirculating filter in the top cover of a consumer-grade hard disk.

Head Crashes

- Causes:
  - Contamination getting stuck in the thin gap
  - Shock applied to the hard disk while it is in operation
- Effects:
  - Cause loss of data
  - Damage to the heads and the surface of the disk

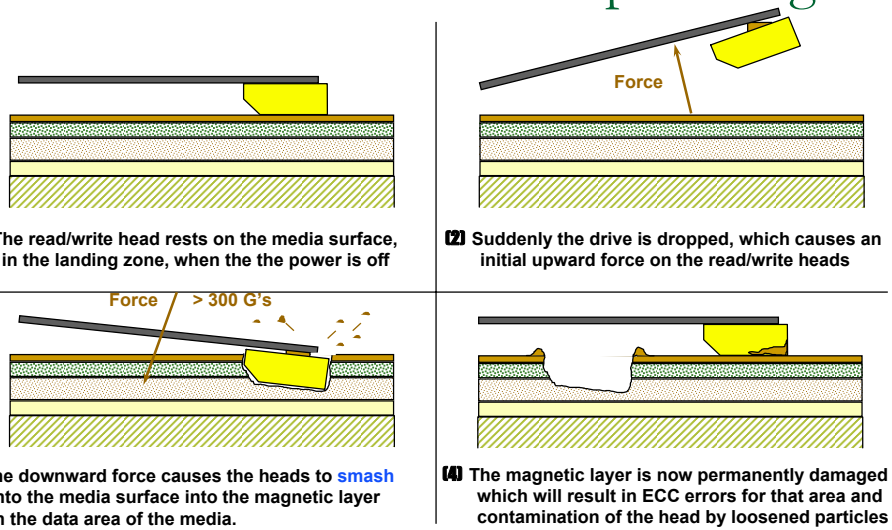
- Despite the lower floating height of modern HDDs, there are many ways less susceptible to head crashes:
  - Superior design of HDD enclosures to eliminate contamination
  - More rigid internal structures and special mounting techniques designed to eliminate vibration and shock
  - Platters usually have a protective layer on their surface that can tolerate a certain amount of abuse before becoming a problem

Shock During Handling is Most Common



- Drives are most suspect to damage when they are being installed, i.e.. ESD, rough handling (shock and vibration)
- A drop of 2 inches onto a hard surface can produce at least 200 G's of shock

Shock Can Cause Head Slap Damage



(1) The read/write head rests on the media surface, in the landing zone, when the the power is off

(2) Suddenly the drive is dropped, which causes an initial upward force on the read/write heads

(3) The downward force causes the heads to smash into the media surface into the magnetic layer in the data area of the media.

(4) The magnetic layer is now permanently damaged which will result in ECC errors for that area and contamination of the head by loosened particles

Handle One Drive at a Time [WD]

Proper handling

Improper handling

Handle in a Safe ESD Environment

Proper handling

Improper handling

Do Not Squeeze the Top Cover and PCBA

Proper handling

Improper handling

Handle Carefully – Avoid Shock

Improper handling

Improper handling

Handle Carefully – Do Not Stack

Proper handling

Improper handling

Handle Carefully – Do Not Place on Edge

Proper handling

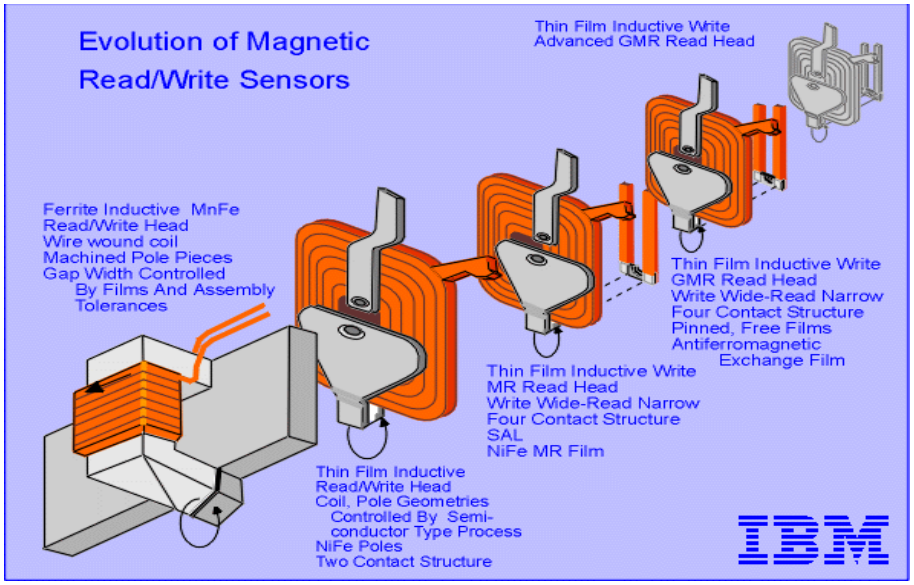
Improper handling

Handle Carefully – Only Use Approved Boxes

Proper handling

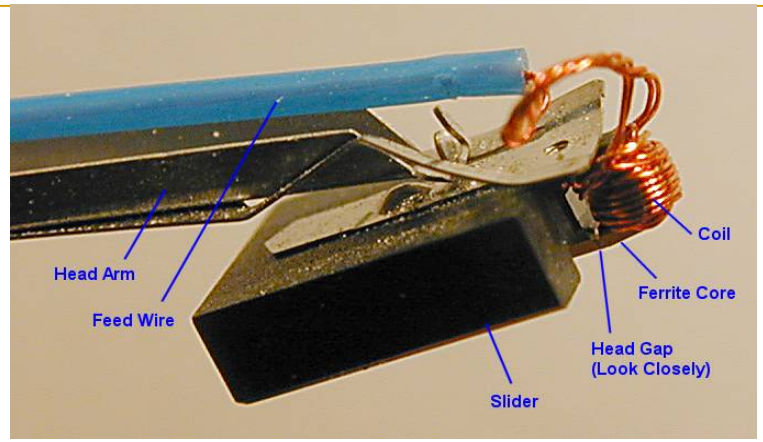
Improper handling

Read/Write Head Technologies



Ferrite Head

- The oldest and the simplest head
- A U-shaped iron core wrapped with electrical windings
- When writing, the current in the coil creates a polarized magnetic field in the gap between the poles of the core.
- When reading, the head is passed over the magnetic fields and a current is induced in the windings.



Ferrite Head

- Large and cumbersome
- Large flying height
- Now no longer used
- Under 50 MB in size

Metal-In-Gap (MIG) Heads

- Same design as ferrite heads, but add a metallic alloy in the head.
- Greatly increase its magnetization capabilities, allowing MIG heads to be used with higher density media, increasing capacity (50 – 100 MB)

Thin Film or Thin Film Inductive (TFI) Heads

- Using a photolithographic process
  - Same technique used to make thin film platter media
- Higher density (100 – 1000 MB)
- Much smaller floating heights