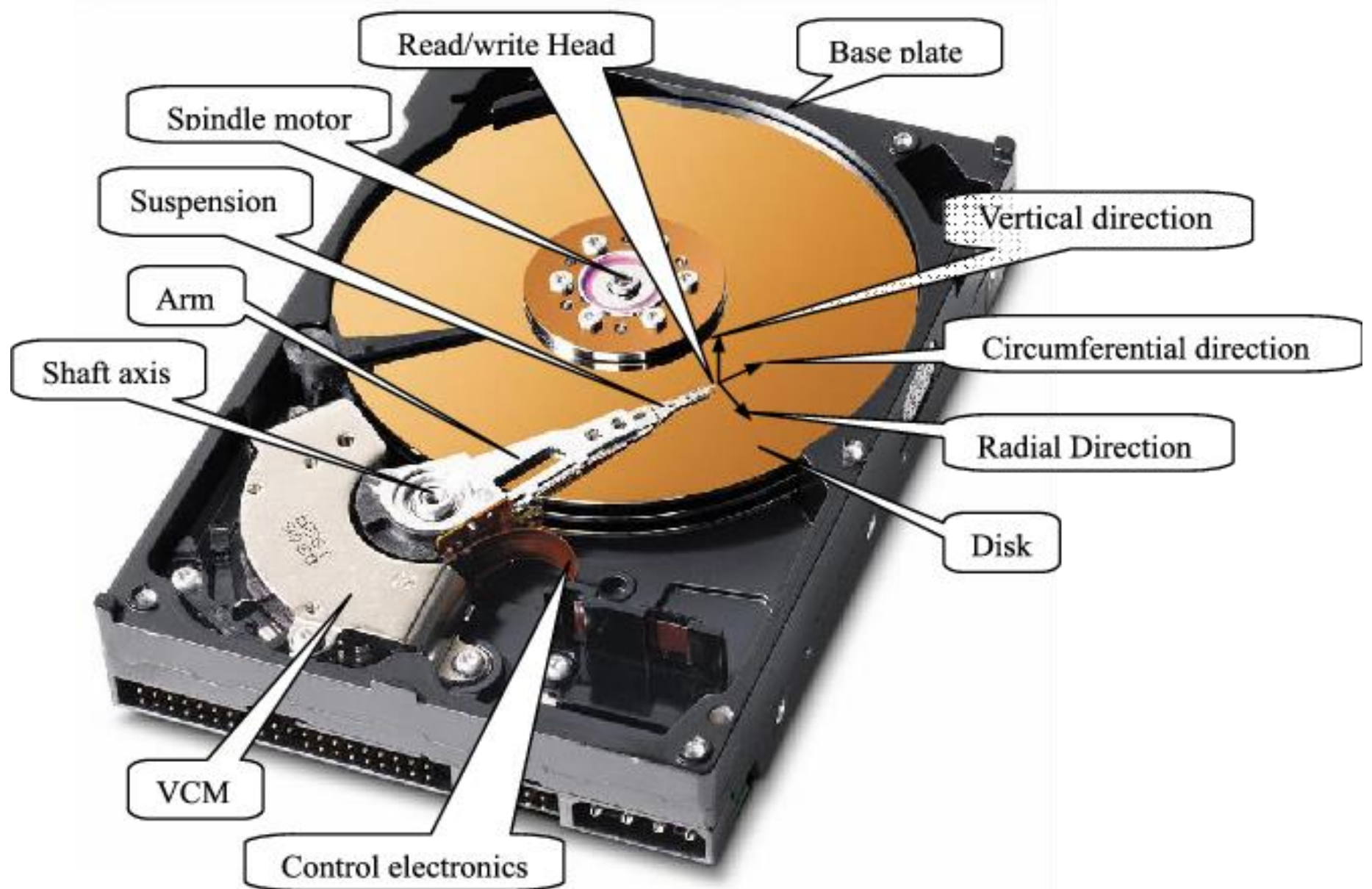


Input/Output Peripherals

Hard disk (HDD)



Hard disk (HDD)

- The hard drive is the organ used to store data permanently, unlike the RAM, which is erased each time the computer is restarted.
- The hard drive is connected to the motherboard via a hard drive controller which manages the drives attached to it, interprets the commands sent by the processor and routes them to the relevant drive.

Hard disk (HDD)

- A hard drive is made up not of a single disk, but of several rigid disks (hard disk) made of metal, glass or ceramic
- The discs are stacked a very short distance from each other and called platters.

Hard disk (HDD)

- The disks rotate very quickly around an axis in a counterclockwise direction (4200 to 7200 rpm).
- There are millions of bits on hard disks, stored very close to each other on a thin magnetic layer a few microns thick, itself covered with a protective film.

Hard disk (HDD)

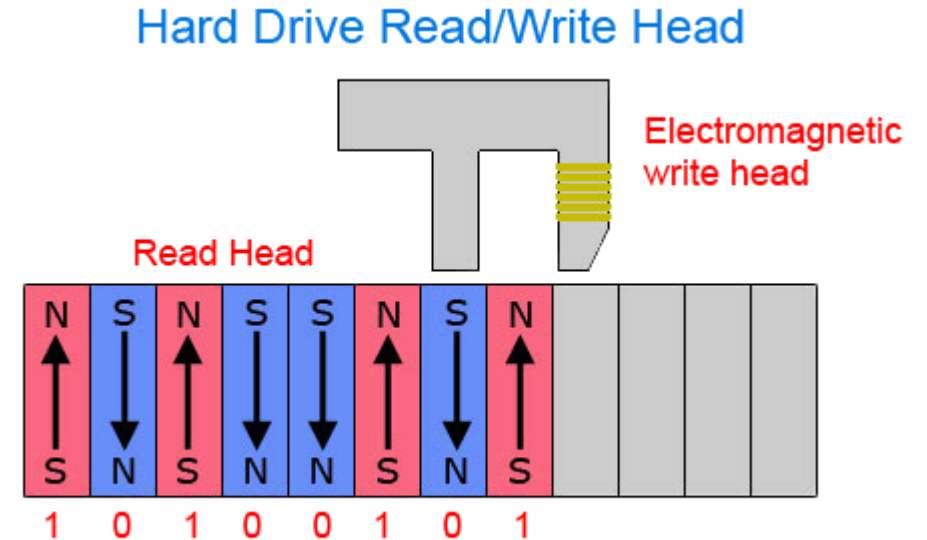
- Reading and writing is done using heads
- There are two L/E heads per tray.
- These heads are placed at the ends of a movable comb which allows the radial movement of the heads.
- These heads are electromagnets that lower and raise to read or write information.

Hard disk (HDD)

- The heads are only a few microns from the surface, separated by a layer of air caused by the rotation of the discs which creates a wind of around 250km/h
- The heads are linked together and only one head can read or write at any given time.
- The set of data stored vertically on all the disks is called a cylinder

Hard disk (HDD)

- The read/write heads are called “inductive”, that is to say they are capable of generating a magnetic field.



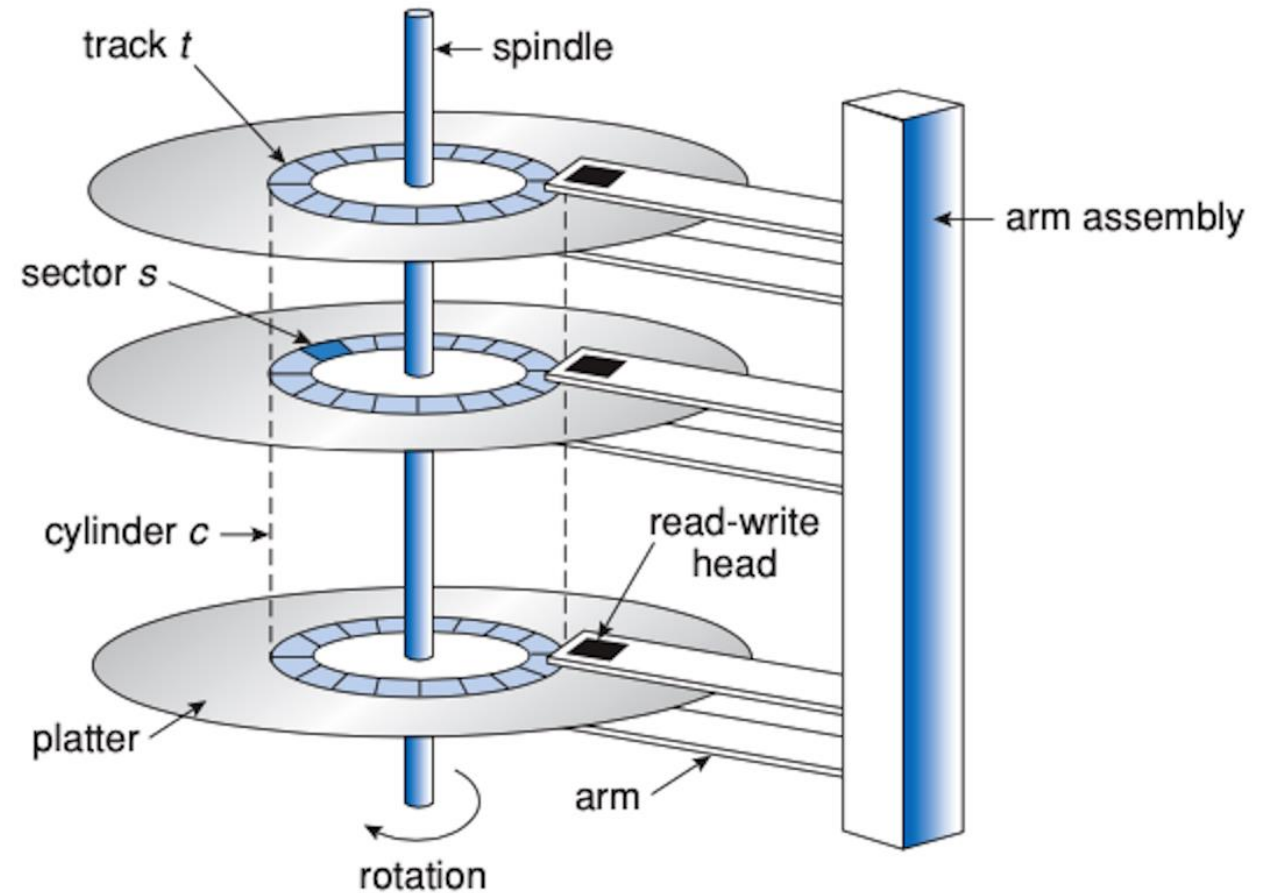
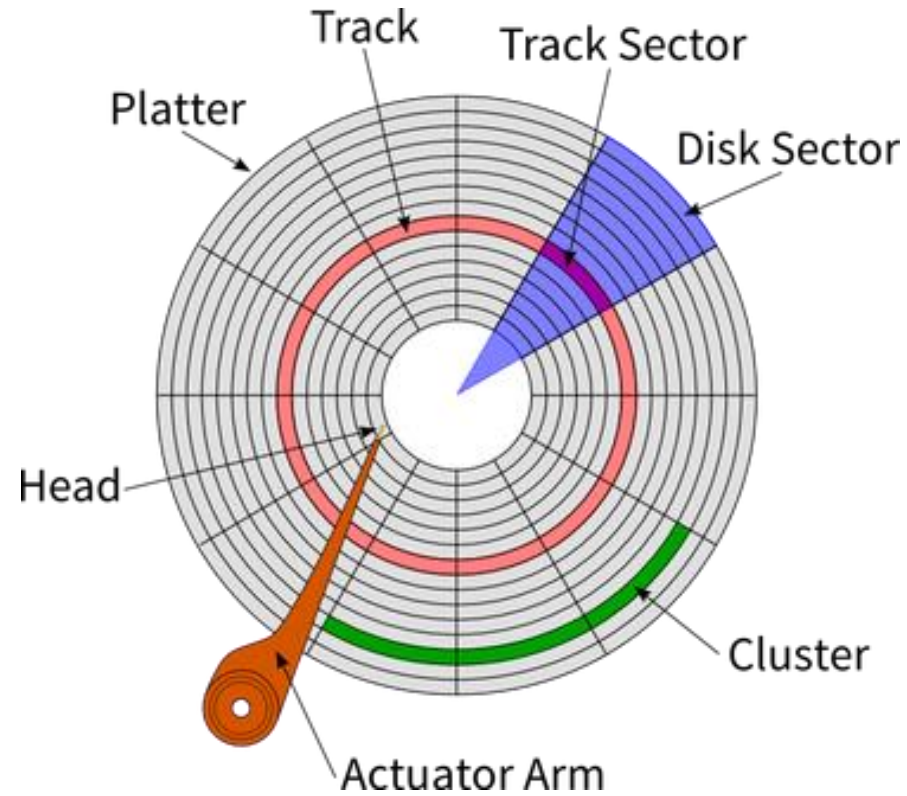
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- The heads polarize the surface of the disk in a very small area, which will result during reading in changes in polarity which will then be transformed by an analog-digital converter into 0 and 1.

Hard disk (HDD)

- The heads start writing data at the edge of the disk (track 0), then move toward the center.
- Data is organized into concentric circles called “tracks,” created by low-level formatting.
- The tracks are separated into quarters called sectors, containing the data.

Hard disk (HDD)



Hard disk (HDD)

- **Capacity**: volume of data that can be stored on the disk.
- **Transfer rate (or throughput)**: amount of data that can be read or written to disk per unit of time.
- **Rotation speed**: speed at which the plates rotate, expressed in revolutions per minute (rpm). The higher the rotation speed of a disk, the better the disk throughput. A disk with a high rotation speed is generally noisier and heats up more easily.
- **Latency time (also called rotational delay)**: time elapsed between when the disk finds the track and when it finds the data.

Hard disk (HDD)

- **Average access time**: average time taken by the head to position itself on the correct track and access the data.
- **Radial density**: number of tracks per inch (tpi: Track per Inch).
- **Linear density**: number of bits per inch on a given track (bpi).
- **Cache memory**: amount of memory on board the hard drive. Cache memory helps preserve the data that the disk accesses most often to improve overall performance;
- **Interface**: this concerns the hard drive connection (IDE, SATA, M2, etc.).

Solid-State Drive(SSD)

- An SSD, for solid-state drive, is computer hardware allowing the storage of data on flash memory.
- The English term solid state designates a semiconductor electronic device or component, therefore without moving parts.

Solid-State Drive(SSD)

Advantages:

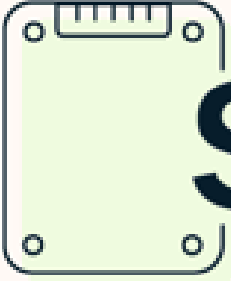
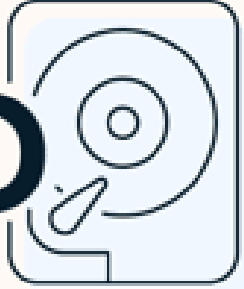
- Particularly low access time,
- Lower power consumption,
- Total silence,
- Its increased resistance to shocks.
- The capacity is currently up to 100 TB
- These drives generally use a SATA interface and are available in 3" ½ or 2" ½.

Solid-State Drive(SSD)

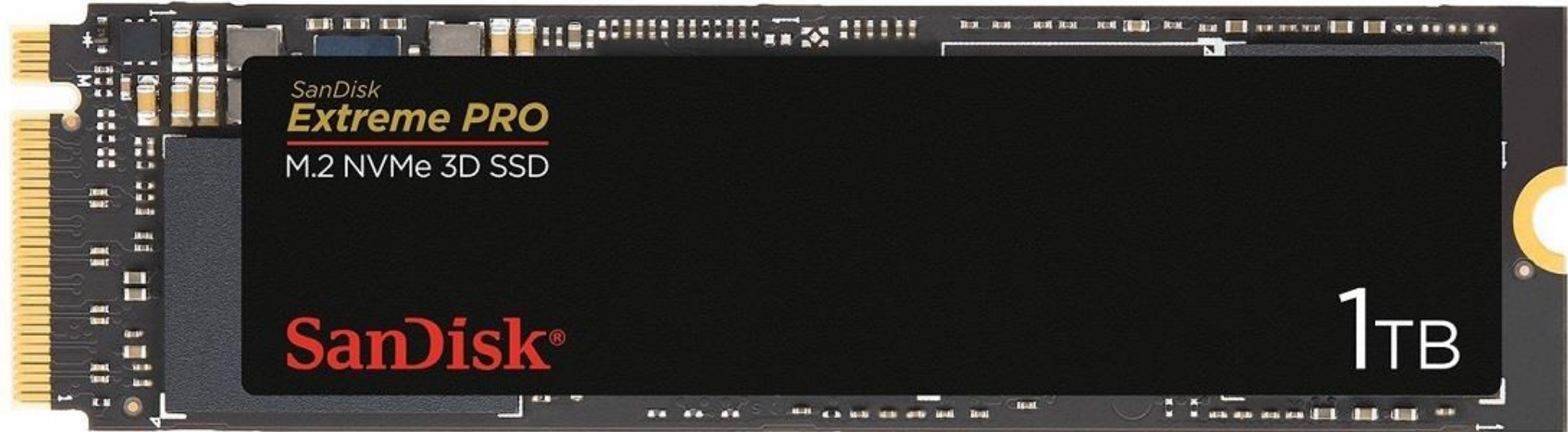
Inconvenient:

- Number of writes to the same area of the “disk” limited to a few hundred thousand.
- The cost.
- There are two different chips on SSDs:
 - MLC (Multi-Level Cell) : Does not allow high transfer speeds to be achieved, Consume much more and a shorter lifespan.
 - SLC (Single Level Cell): Top of the line

HDD vs SSD

	SSD	vs	HDD	
faster	✓		✗	slower
more expensive	✗		✓	cheaper
non-mechanical (flash)	✓		✗	mechanical (moving parts)
shock-resistant	✓		✗	fragile
best for storing operating systems, gaming apps, and frequently used files				best for storing extra data, such as movies, photos, and documents

NVMe Drive



NVMe Drive

- NVM Express for Non-Volatile Memory (also abbreviated NVMe) is an interface specification allowing a computer to access a permanent storage device through a PCI Express bus.

NVMe Drive

- This involves providing efficient access to flash memory without using the SCSI disk protocol.
- By design, NVMe enables the parallel access potential of flash memory-based systems to be exploited.
- It is possible to reach 3 million IOPS (input/output operations per second) with a system of this type, where Serial ATA (SATA) caps at 150,000 IOPS.
- Its theoretical maximum bandwidth is 8 GB/s in PCI Express 4.0.

USB sticks and flash memories

- Devices that store information long-term in solid-state memory that does not erase.
- The technology is based on the use of “flash” memories which are made up of small elementary cells which each behave like a small capacitor which is capable of retaining its charge for a very long period (10 years).

USB sticks and flash memories

- During reading, we measure the field induced by the charge of the cell to know the state of the bit.
- To write to a flash memory, you must first “erase” the cells.
- For technical reasons, they must be erased all at the same time and then rewritten (hence the term “flash” which refers to this operation).

USB sticks and flash memories

- In practice, for large capacity memories, manufacturers partition their circuits into several blocks and each of the blocks can be erased and rewritten individually.
- On most of these memories, a mechanical switch protects the data by prohibiting writing.

Optical discs

- The use of optical processes makes it possible to increase the maximum density of information that can be recorded per unit area.
- The surface of optical discs is also divided into concentric tracks, but optical processes are used to read the information.

Optical discs

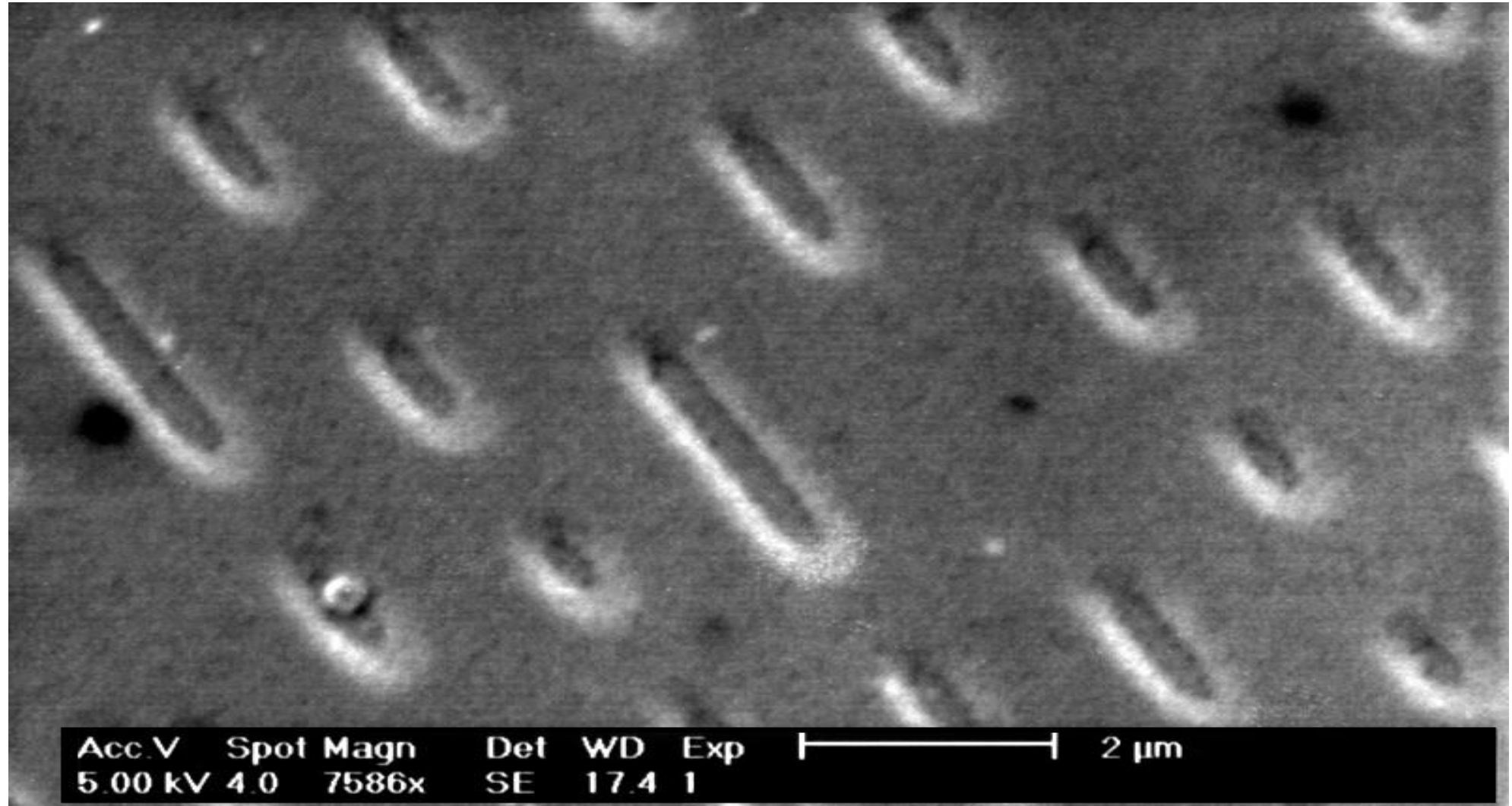
- It is the fluctuation of the reflection of a thin laser beam on the surface which allows digital information to be reread.
 - No reflection = 1
 - Important reflection: = 0
- These processes are the basis of digital compact disc (CD) players used by the general public.

Optical discs

- Computer CD-ROMs (Compact Disk - Read Only Memory) can hold 720 MB of easily accessible information.
- They are mainly used to distribute general information.
- However, it is not possible to change their content which is permanently fixed.

Optical discs

- CD-ROM



Optical discs

- WORM drives (for Write Once, Read Many) allow you to write to special optical disks by modifying their surface.
- You cannot change what you have written, but the information can be reread as often as you want.
- This type of disk is primarily intended for archiving.

Optical discs

- When recording on a CD±R, the data is written by raising the temperature (burning) using a laser pulse which heats the organic material (initially transparent) beyond its critical polymerization temperature.
- It then becomes irreversibly opaque.

Optical discs

- The power of the laser is of the order of 10 mW and can very quickly bring the focus point in the photosensitive resin to a temperature of around 250°C.
- During playback, the intensity is varied depending on the transparency.
- CD±Rs have pre-traced tracks which will be modulated by the writing laser.

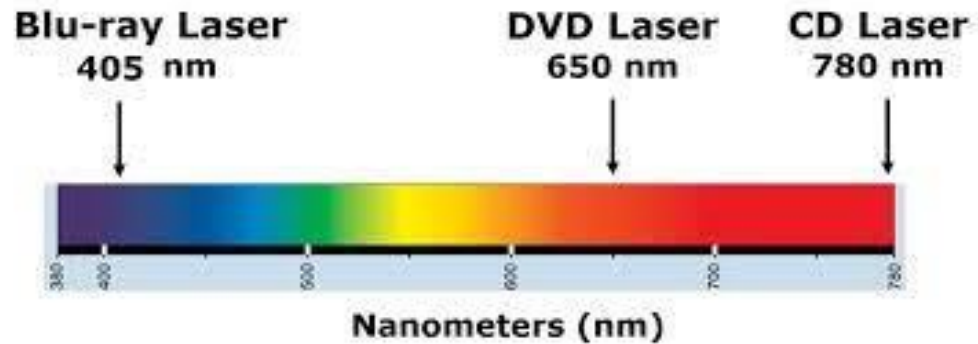
Optical discs

- For rewritable discs (\pm RW), the change in state of the photosensitive material is reversible.
- To erase, a lower but continuous laser power is used which slightly heats (200 degrees) the entire volume of the polymer which becomes liquid and which cools into the crystalline state.
- This type of disc reflects light less well than a conventional disc and can therefore only be read by suitable “Multiread” players.

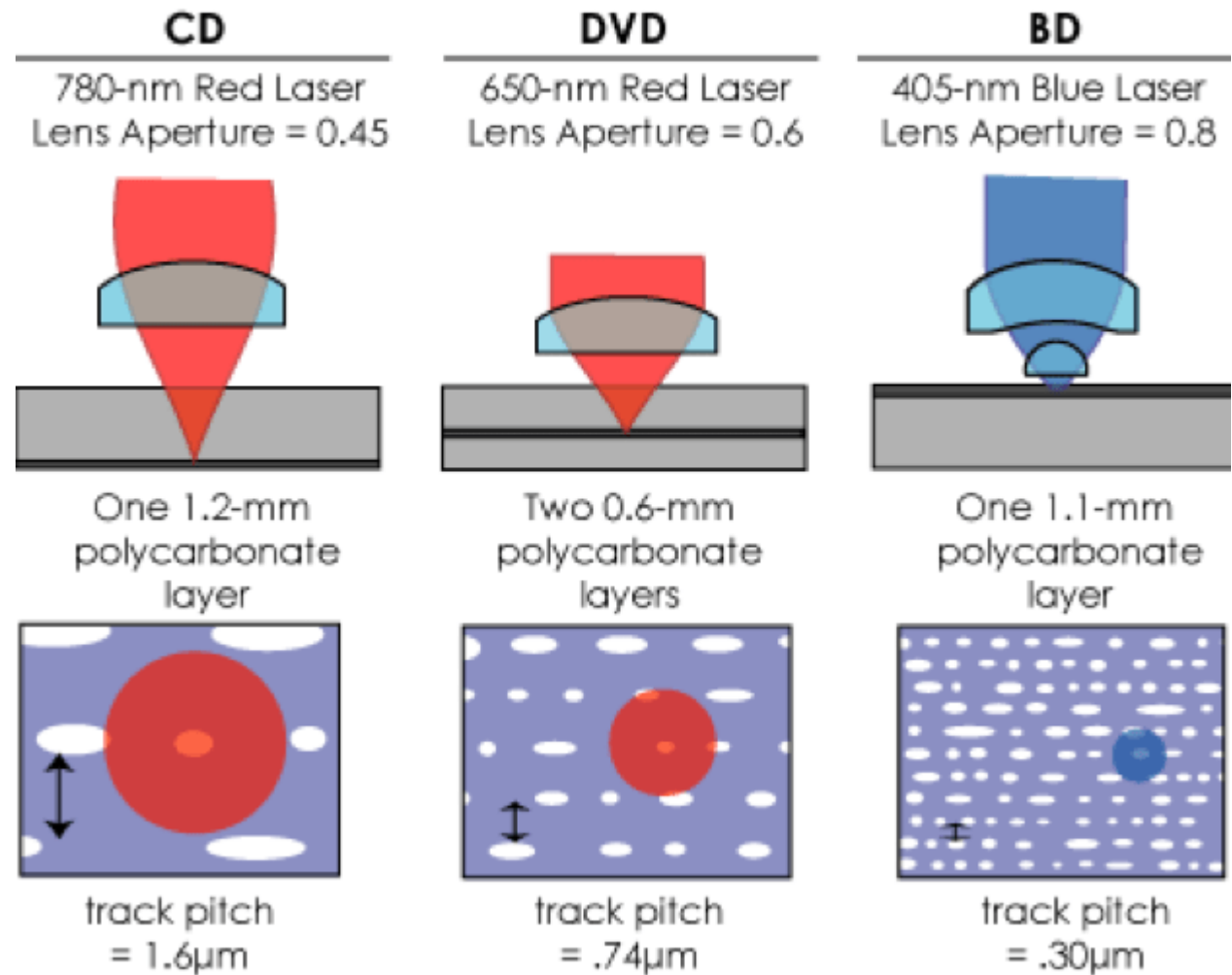
Optical discs

- A CD contains approximately 720 MB of information
- A DVD uses denser encoding and can store 4.7 to 9.4 (double layer) GB.
- Blu-ray is the most efficient optical disc with a storage capacity of up to 200 GB.

Optical discs



CD vs. DVD vs. Blu-ray Writing



Graphic tablet

- A graphics tablet allows you to record the movements of a special “pencil” that is moved across its surface.
- Graphic tablets make it possible, for example, to “read” manual writing electronically or to reproduce the drawing that is traced on its surface.

Graphic tablet

- An optical pencil allows you to designate a particular area of the screen by positioning the active end of the pencil on it.
- The pencil does not write, it contains a light sensor which detects the passage of the writing spot on the screen and retransmits the coordinates of this point to the computer.

Mouse

- A mouse is a device that controls the movement of a pointer on the screen.
- It typically has one or more buttons that the user can press to request an action.
- The mouse allows you to move the pointer to particular areas of the screen.

Touch screen

- Touchscreens respond to touch.
- Two detection techniques are used:
 - The first consists of placing a transparent device in front of the screen, sensitive to pressure, which allows the coordinates to be found.
 - The other method consists of surrounding the screen with a large number of emitting diodes (LEDs) coupled with detectors facing them.

Keyboard

- A keyboard is used primarily for typing text on the computer.
- It comprises:
 - keys for letters and numbers, as well as special keys.
 - Function keys.
 - The numeric keypad.
 - Navigation keys

Cathode ray tube screens

- The cathode ray tube displays a color image produced by a flow of electrons which strikes the active surface of the tube.
- Each point of light (pixel) on a color screen is made up of three materials
- Each of these materials produces a color (red, green, blue) if it is subjected to a flow of electrons.
- There are three electron cannons and each cannon can only light up dots of one color.

Liquid crystal displays (LCD)

- An LCD screen uses the polarization of light to produce an image through transparency.
- It is composed of several superimposed layers including two polarizers sandwiching a layer of liquid crystals in nematic phase whose orientation can be locally varied depending on an electric field.
- Depending on the polarization, light passes or does not pass.

Liquid crystal displays (LCD)

- From an optical point of view, the liquid crystal display is a passive device.
- There are several lighting modes:
 - Reflective lighting: The screen operates only by reflection of incident light. The advantage is low power consumption and brightness naturally adapted to ambient lighting, but they are unreadable when ambient lighting is low.
 - Transmissive lighting: The screen operates with backlighting provided by one or more lamps.

Plasma Display Panel

- It consists of a “sandwich” made up of two sheets of transparent material, between which a honeycomb structure composed of numerous cells is incorporated.
- Each cell of a plasma screen is an independent light source and whose operation is very similar to that of a fluorescent lamp
- A pixel is made up of three discharge cells emitting light in the three fundamental colors.

Plasma Display Panel

- The plasma of each cell is created by the passage of current in a rare gas (xenon-neon mixture) and emits ultraviolet photons converted into visible photons by phosphors of different colors placed on the walls of this cell.
- The difficulty is to electronically control each micro-plasma using row and column electrodes placed on two facing glass slabs and separated by approximately 100 microns.

OLED screen

- The screen is made up of a myriad of light-emitting diodes (LEDs) grouped in 3 (one red, one green and one blue) and forming the pixels of an OLED screen.
- The whole thing rests on a transparent “substrate”, made of glass or flexible plastic.
- OLED technology has many advantages over LCD (low power consumption, better color rendering, better contrast, thinness and flexibility of the support, etc.).

OLED screen

- The only weak point being the lifespan which is not yet optimal (around 100,000 hours).
- This technology is intended to gradually replace liquid crystal displays.

Needle printer

- It features a movable print head that contains a number of vertically aligned needles.
- Each needle can be propelled forward by an electromagnet.
- Each time a needle is moved, it compresses the ink ribbon on the paper, which prints a small black spot ("dot").

Needle printer

- The head moves at a constant speed from left to right and prints a complete line with each pass.
- After each scan, the paper is advanced by the distance of one line space.
- Adequate electronics activate the electromagnets very quickly to form an image from a very large number of small contiguous spots.

Needle printer



Laser printer

- A rotating drum coated with selenium receives a uniform electrical charge as it passes a brush raised to a very high electrical potential.
- The regions which are illuminated by the laser beam lose their charge by photoelectric effect.
- The intensity of the laser is controlled by a complex electromechanical device which sequentially reproduces the image of the document on the drum in the form of a very large number of longitudinal lines (12/mm).

Laser printer

- The drum passes above a tank containing a very fine powder which is attracted by an electrostatic effect and sticks to the charged areas of the drum.
- The drum is pressed on the paper and the powder comes off the drum to become embedded on the paper.
- The paper then passes through an oven which melts the glue contained in the powder, which permanently fixes the image.

Inkjet printer

- The characters are formed by the juxtaposition of a very large number of small spots produced by projecting very fine droplets of ink onto the paper.
- The projection mechanism consists of several extremely fine nozzles mounted vertically on a movable print head.
- The droplets are projected by the overpressure induced by a mini-resistor, or by piezoelectric effect.

Thermal paper printer

- These printers use special paper that darkens when heated.
- They work according to the same principle as in needle printers, but the print head is made up of several mini-resistors whose heating causes the paper to blacken each time the current flows through these resistors.
- The surface of the paper is covered with a multitude of micro-bubbles whose surface is white and the content black.

Thermal paper printer



Plotter tables

- A plotter allows you to precisely move a pen across the surface of the paper.
- The computer controls the movements of the pen and constructs the desired image through a series of movements.
- Some plotting tables allow you to produce large drawings.
- This type of printer is especially suitable for producing technical drawings or electrical diagrams.

Plotter tables

