Unit 4

Monitor and display Adapters

Monitor

A monitor is used to display the output of any computer system. A good display makes all the difference and no doubt enhances the user experience. The innovation in the display technologies has improved the quality of the display devices including monitors. Now the desktop computers are available with a variety of displays ranging from technologically obsolete **CRT monitors** to latest slim **LCD, LED or OLED monitors**.

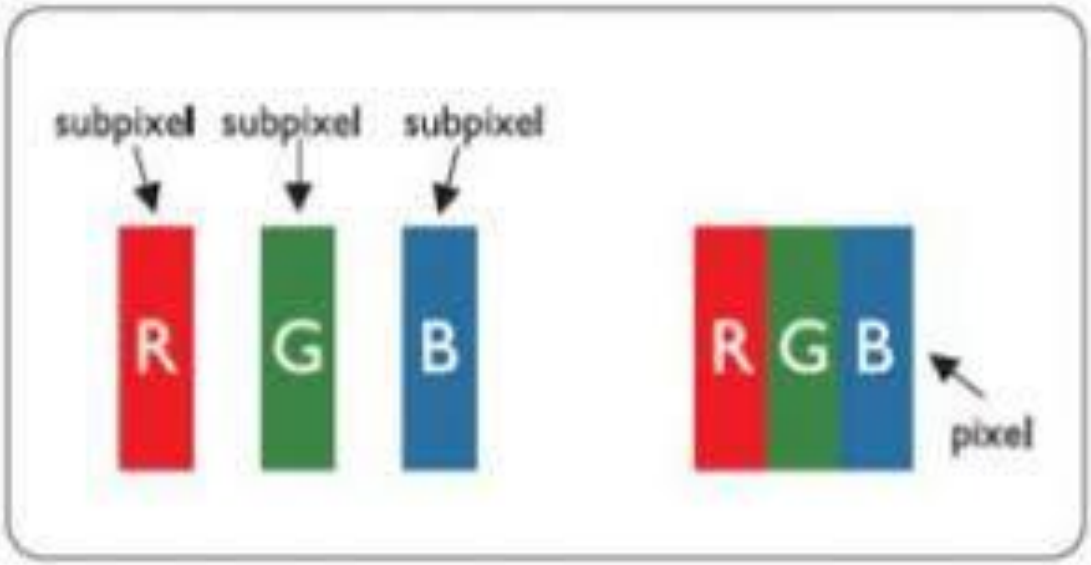
Definition-A computer monitor, technically termed as visual display unit is an output device that presents the information from the CPU on the screen working as an interface between CPU and the user. A cable connects the monitor to a video adaptor or video card which is set up on the motherboard of the computer. The CPU (Central Processing Unit) sends instruction to the video adaptor telling what needs to be displayed on the screen. The video adaptor converts the instructions into a set of corresponding signals and sends to the monitor. Monitor contains a circuitry that generates the picture on the screen from the set of signals.

The major parameters that measure the performance of a monitor are luminance, contrast ratio, resolution, dot pitch, response time, refresh rate and power consumption. The common problem that arises in monitors is dead pixels, blurred screen, phosphor-burn, etc.

Related terminologies/Terms

- **Dots and Pixel**
    - Picture Element
    - It is the smallest element forming an image.

Dots-The images displayed on a Pc's monitor are created from a pattern of dots. Dots are shaded lighter or darker so that your eyes can form a visual image from them. The CRT creates these dots from the phosphor on the back of its screen using masking methods.
A monochrome or single color monitor has a phosphor of only one color, so that when the phosphor dots are illuminated, the text and graphic image is a single color on a contrast background. Typically background is black and display color is white or green.
Pixel-The image produces on a color monitor is created by illuminated small triangles of phosphor dots called picture elements or pixels.in the CRT one-third of the dots are red dots, one-third are green dots and one-third are blue dots



A color CRT has three electron guns that are used to light up the phosphors in each pixel

- Resolution
    - No. of pixels per unit video display
    - Video Graphics Array (VGA): – 720 pixels across by 400 pixels down in text mode
      – 640 pixels across by 480 pixels down in graphics mode.

      The number of pixels on a monitor, whether CRT or LCD, determine the amount of detail that can be used to create an image.as the number of pixels increases, image resolution increases image quality also increases. The number of pixels on a monitor is its resolution, which is expressed in the number of pixels on each row of the display and the number of rows of pixels on the display. For Eg.VGA standard resolution is 640 X 480 means a monitor has 640 pixels arranged horizontally on each row of pixels and 480 vertical rows of pixels
- Display Size
    - Measured as distance from one corner to the diagonally opposite corner.
    - Usually measured in INCHES.
- Viewing Angle
    - It is angle from which the screen can be seen from side.
    - It is larger for CRT as compared to LCD
- Response time
    - The minimum time necessary to change a pixel's color or brightness.
- Brightness
    - The amount of light emitted from the display (more specifically known as luminance).
- Color Depth
    - Color depth of a monitor is the maximum number of colors that it can display

- It is represented as the number of bits required to hold the number of colors .for eg. 8 bit color depth has a maximum of 256 colors

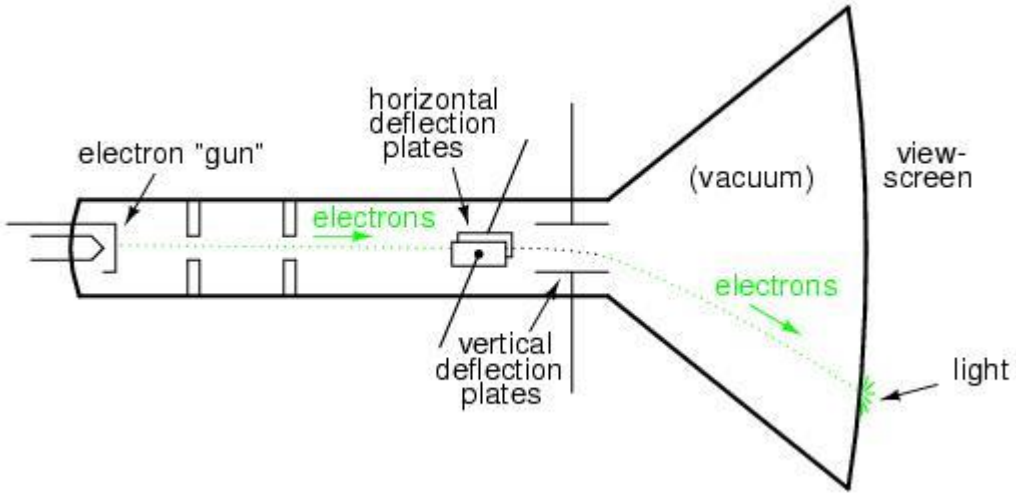
- Refresh Rate
  - The number of times per second that the screen is redrawn/refreshed
- Aspect Ratio

  Aspect ratio of a monitor is the relationship of its height (in pixels) to its width (in pixels).most CRT resolution has aspect ratio 4:3.It help the software to determine how to place images on the screen in relationship to each other.

Display Technologies

Since the beginning of computer era, there have been a number of technologies used for the display of output. The major technologies are CRT, LCD, Plasma, LED and OLED displays.

1. Cathode Ray Tube (CRT) Monitors



Parts-

- **An Electron Gun**-used to produce a stream of electrons
- **Focusing and Accelerating anodes**-used to produce a narrow and sharply focused beam of electrons.

- **Horizontal and vertical deflecting plates-**moving beam horizontally and vertically for controlling the path
- **Screen-**a glass envelop having a phosphor coated screen at its flared end which produces a bright spot when struck by a high velocity electron beam. This phosphors material is arranged into an array of millions of tiny cells called dots.

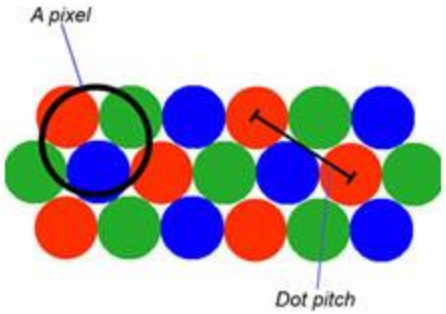
Working

- **CRT** is an glass tube with a florescent coating on the inner front surface ,which is called screen
- An electron gun at one end emits an electron beam
- Beam is directed towards the screen
- When the beam strikes on the screen ,the phosphor coating on the the screen illuminate at that spot
- Electron beam is deflected horizontally and or vertically using vertical and horizontal deflecting plates
- Beam is turned on or off to produce an image
- Video information from the computer is used for turning the beam on or off at appropriate places when the beam scans the screen.

Color Monitor operation

When electrons strikes the phosphor coated screen passing through a mesh (shadow mask or aperture grill), the phosphor lights up making a displayable dot on the computer screen. There are three different colored phosphors (Red, Green and Blue) for each pixel and the color of the pixel depends on the phosphor on which the electrons strike.

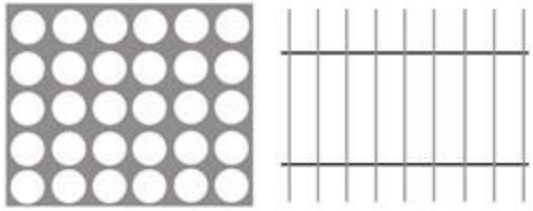
This image shows the color combination schematic for phosphor particles. The monitor that has a single electron gun has three



different phosphors for each pixel. A cathode ray strikes to one or more of these phosphors and the corresponding colored pixel appear on the screen. However high quality monitors use individual electron gun for each color which improves the image quality. Distance for two same colored phosphors (for single electron gun monitors) is known as dot pitch. Lesser the dot pitch higher is the quality of monitors.

Aperture Grille v/s Shadow Mask

CRTs incorporate a metal sheet behind the display screen which affects the pixels on the screen as well as brightness on the screen.



Shadow mask and Aperture Grill

Shadow mask is an obsolete technology in which there is a metal sheet with millions of holes to pass electrons in order to hit the phosphor coating. The shadow mask covers the entire screen thereby protecting the phosphors from stray ions (due to vacuum) and also limits the strength of the rays reducing the brightness on the monitor.

Aperture grille is a mesh of wires rather than any metal sheet with holes in it. Although the grill is fragile, it allows a brighter display.

LCD Monitor

LCD Monitors

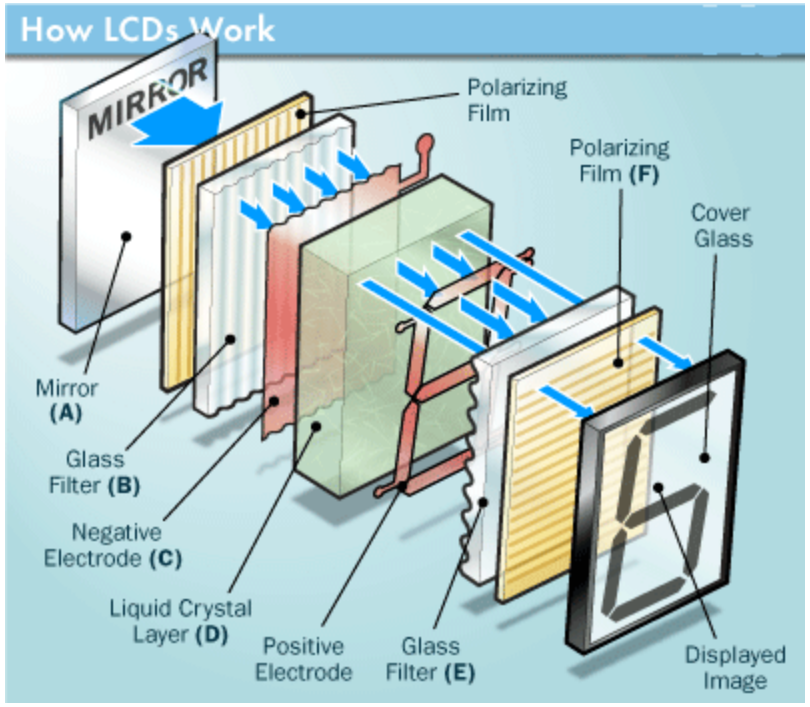
LCD, Liquid Crystal Display or also known as Liquid Crystal Diode is one of the most popular display technologies currently. LCD monitors are lightweight, compact, occupy less space, consume low power and are available in a reasonable price.

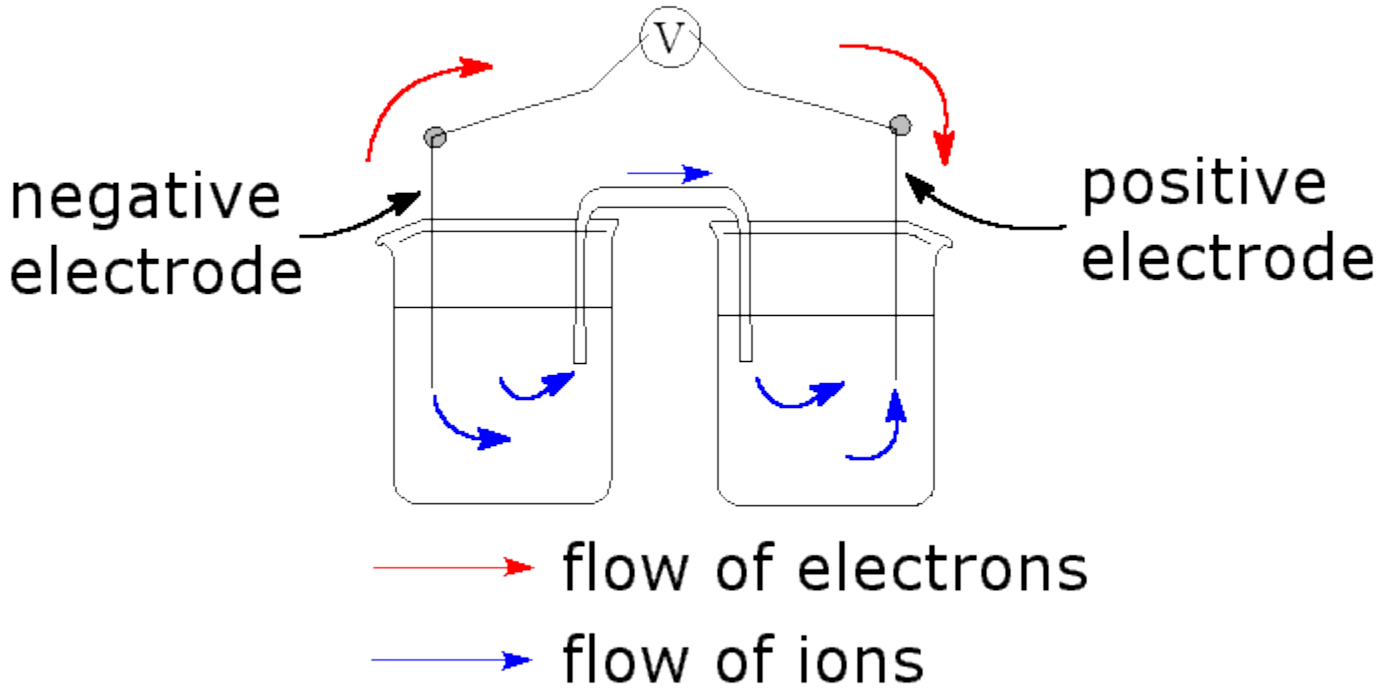
Currently there are two types of LCD technology in use

- Active matrix LCD technology or TFT and
- Passive matrix technology.

The TFT technology is more reliable with better image quality while the passive matrix technology has a slower response and gradually becoming outdated.

As the name indicates, liquid crystals are the key elements of the display screen. By manipulating the crystal we can change the way they interacts with the light. There is a display controller in the monitor which receives the display signals from the video adaptor in the motherboard. The display controller controls two things – the electric signals to the liquid crystals and the back light. Structure of an LCD is shown in the below images (Also see how LCD works).


How LCDs Work
MIRROR
Polarizing Film
Polarizing Film (F)
Cover Glass
Mirror (A)
Glass Filter (B)
Negative Electrode (C)
Liquid Crystal Layer (D)
Positive Electrode
Glass Filter (E)
Displayed Image



Layers in LCD

- Mirror-the back of the LCD is a mirror for reflecting light
- Polarizing Film-A piece of glass coated with a polarizing film on its back
- Electrode-the common electrode plane for the assembly. Electrodes in LCDs function as on and off switches. The electrodes tune their voltage from on to off in 256 increments for each RGB subpixel. This is what gives 16.7 million different colors.
- Liquid Crystal-A layer of twisted nematic liquid crystal
- Electrode-a layer of glass with one or smaller electrodes attached
- Polarizing Film-another layer of polarizing film at a right angle to the other layer of polarizing film.

Working

1. A light source emit unpolarized light.
2. When it passes through the rear polarizer (say vertical polarizer), the light will become vertically polarized.
3. Then this light enters to the liquid crystal. As we seen before, liquid crystal will twist the polarization if it is ON. So when the vertically polarized light passes through ON liquid crystal segment, it becomes horizontally polarized.
4. Next is front polarizer (say vertical polarizer), which will block horizontally polarized light. So that segment will appear as dark for the observer. If the liquid crystal segment is OFF, it will not change the polarization of light, so it will remain vertically polarized. So the front polarizer will pass that light. So it will appear as bright (not dark) for the observer.

The liquid crystals used in the LCD are Twisted Nemantic (TN), a type of liquid crystals that are twisted at 90degree with the surface. In this state, crystals allow the light to pass through the polarizer but on applying a voltage, they get untwisted and block the light to passing through the polarizer. The display controller starts the backlight that passes through the first piece of the glass. At the same time the display controller also send the electrical currents to the liquid crystal molecules to align and allowing the varying level of light to pass through the second piece of glass, forming the desired picture on the screen. In color monitors, **each pixel is made of three liquid crystal cells fronted with red, green and blue filters**. The light passing through the filtered screen forms the color what you see on the monitor. A wide range of colors are formed by varying the intensity of colored pixels.

The backlight is made of cathodes, and depending on the quality of the monitor, there may be a single cathode at the top or one at the top and one at the bottom, or two at the top and two at the bottom to improve the brightness and clarity of the monitor. These cathodes are diffused through a layer of plastic and diffusing materials.

Resolution - Unlike the CRT monitors there is no complex equation for the dot pitch and the resolution. The resolution of a monitor is simply the number of pixels contained in the matrix. Typically a 17 inch monitor has a resolution of 1280 x 1024 pixels.

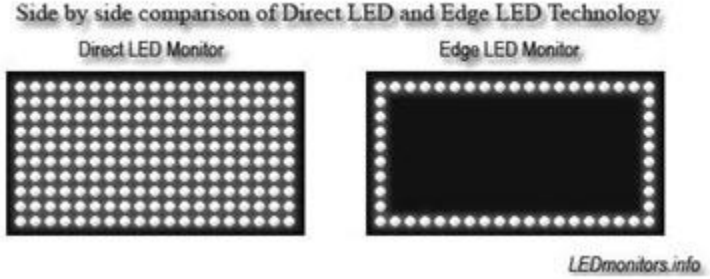
LED Monitors

LED Monitors

In the previous decade, the display technology has changed significantly. LED displays are one of the latest developments in this field. LED monitors use light emitting diodes that acts as a performance booster in the monitors. Basically LED monitors are the LCD monitors with **a LED backlight to power up the LCD panel**. It means that LEDs are placed behind or around the LCD panel to enhance the luminosity and video definition of the monitor screen.

As we have seen in the above section of LCD monitors, they use a cold cathode light as backlight. In the LED monitors all the concepts are same except **this backlight, which is replaced by LEDs.**

There are three different types of LED monitors available based on the manner how the diodes are arranges in the monitor. These are – **Direct LEDs, Edge LEDs and RGB LEDs.** Both Edge and Direct LED display monitors use white diodes that are used to illuminate the LCD panel to produce the improved picture quality. The arrangement of LEDs in the monitor is shown in the below image:



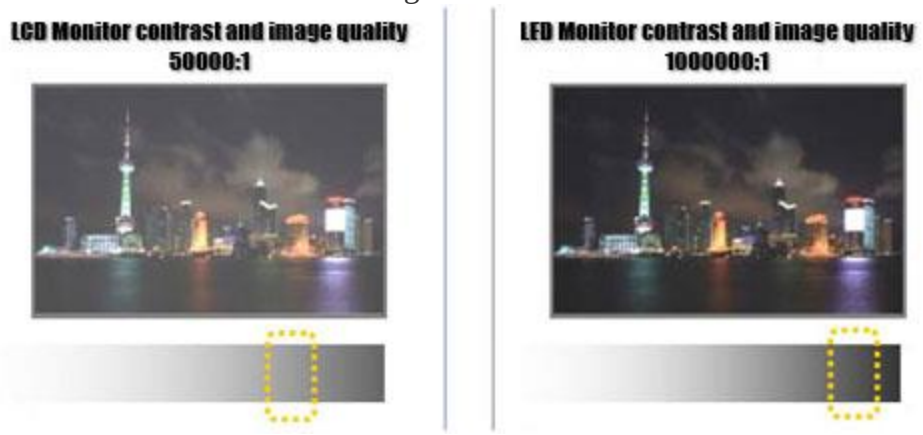
In the Direct LEDs display, white diodes are placed all over the panel to produce higher quality image while the Edge LEDs display

uses LEDs only on the borders of the LCD panel. Direct LEDs are generally used in the production of high definition TV whereas the Edge LEDs is mainly used in the production of computer screens. RGB LEDs display is better among the three types of LED monitors as it uses red, green and blue diodes to produce the lifelike images with amazing contrast ratio.

LCD v/s LED Monitors / Why LED displays are better than the LCD displays:

Both types of monitors work on the same technology. LED monitors are LCD monitors with replaced cold cathode backlight to LED backlight. Here are the differences that make the LED displays better than the LCDs:

- Contrast and Black level of the LED screen is better than the LCD screens because the liquid crystals cannot stop 100% of the backlight from cold cathode backlight and hence when the black screen is to be shown on the monitor, it is not completely black (as shown in the below image). But Edge LED screens perfectly show the black screen as there is no backlight at all.



- Color accuracy for direct and edge LED displays and LCD displays are almost same but the RGB LEDs display has quite better color accuracy.
- When comparing the LED and LCD monitors with respect to viewing angle, they are same as backlight has nothing to do with viewing angles.
- LED displays consume less power. It is reported that they consume up to 40% less power than the LCD displays.
- LED displays do not use mercury (used in cathode lamps in LCD backlight) so they are environment friendly.

- The size of Edge and RGB monitors is slight thinner than the LCD monitors while prices are slight higher.

Plasma Monitors

Plasma Monitors

Plasma technology is another technology used in display devices. The basic idea behind the plasma technology is to illuminate tiny

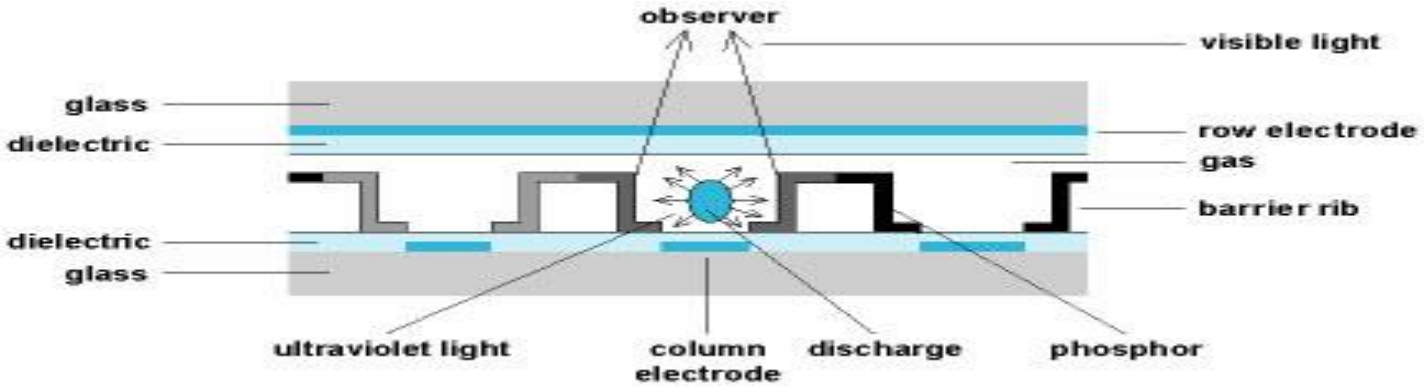
colored fluorescent lights to create image pixels. Each pixel is made of three such fluorescent lights – red, green and blue lights. To create a wide range of colors, intensity of these lights is varied accordingly.

The heart of plasma displays is plasma which is basically a gas (generally Xenon and Neon) made up of free flowing electrons and ions. When the electrical current flows through the plasma, negatively charged particles move towards the positively charged area of the plasma and vice versa. This makes collisions which resultantly excite the gas atoms in the plasma and then release the energy as photons of light.

There are millions of tiny cells filled with the gas like xenon and neon. They are positioned between two plates of glass known as front plate glass and rear plate glass. Two transparent electrodes covered by an insulating dielectric material and a magnesium oxide protective layer are also sandwiched between the glass plates on both sides of the cells on the entire screen.

Working

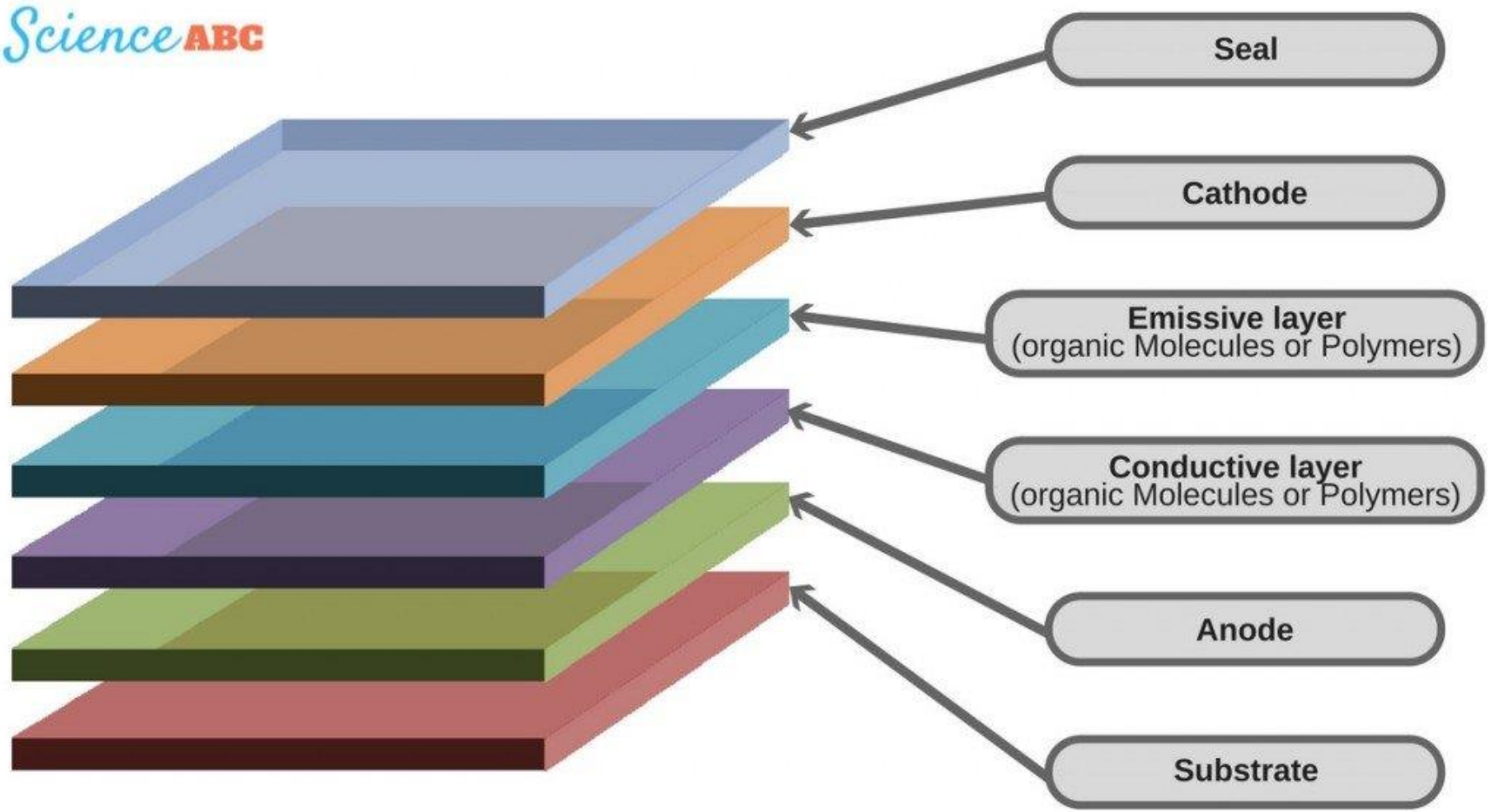
1. When the CPU sends the signals to the Plasma monitor, the corresponding electrodes are charged which ionizes the gas in the intersecting cells by passing an electric current.
2. Due to the collisions between the gas ions they release energy in the form of the photons of light which illuminate the respective cells.
3. This process occurs thousands of times in a small fraction of second making the display faster.
4. The released ultraviolet photons strike the phosphor material coated on the inner wall of the cell and hence phosphor electrons jump to the higher energy level.
5. When the electron falls back to its normal state, it releases the energy as a visible light photon. Every pixel on the screen is made of three different colored phosphors – red, green and blue.



OLED Monitors

OLED Monitors

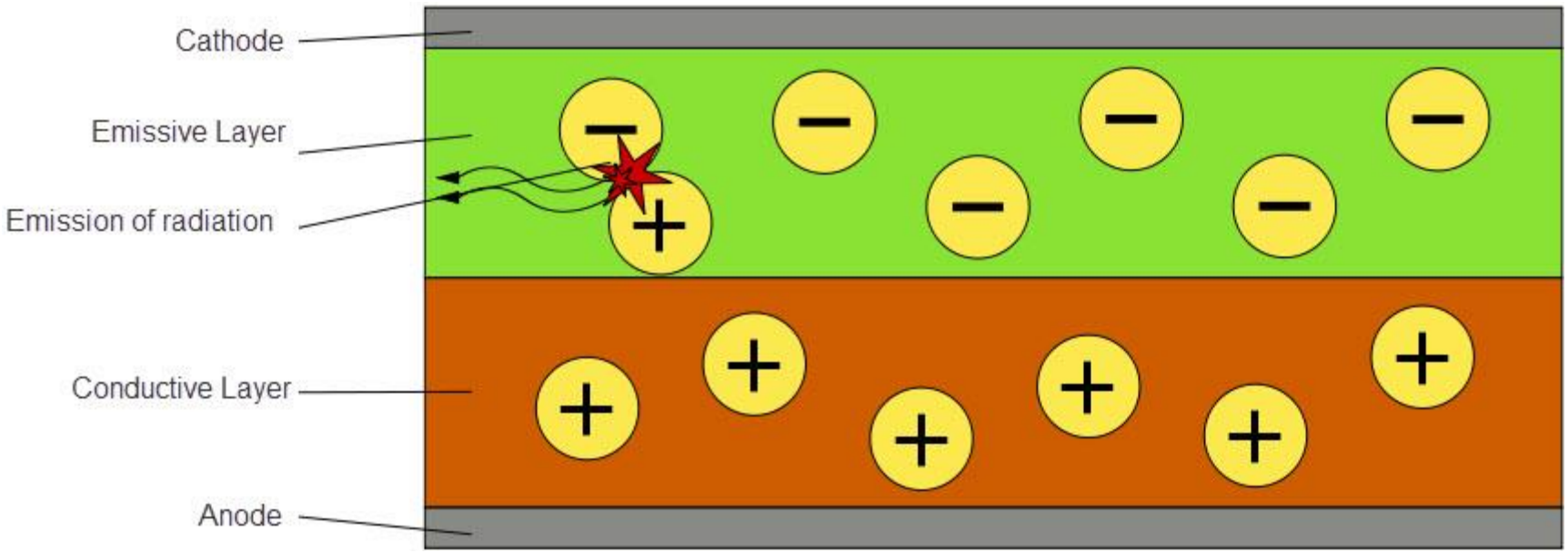
OLED, short for **Organic Light Emitting Diode** is the latest technology for display devices. As the name suggests there are some organic material (**containing carbon, like wood, plastic or polymers**.) that is used to convert the electric current into light. Since the LEDs are capable of producing different colored light, they are directly used to produce the correct color and there is no need of a backlight which saves power and space. With fast response time, wide viewing angles, outstanding contrast levels and perfect brightness, OLED displays are surely better than the existing other display technologies.



OLED consists of six layers – the outermost layers are called the seal (the top layer) and the substrate (the bottom layer). Next come the anode (a positive terminal) and cathode (a negative terminal). Sandwiched between these layers are the emissive and conductive layers.

1. When an appropriate voltage is applied, an electric current flows from cathode to anode through the organic layers.
2. The cathode give electrons to the emissive layer of organic molecules while the anode takes equivalent electrons from the conducting layer of organic molecules.
3. At the boundary of emissive and conductive layers, electrons and the holes are gathered.
4. Here electrons are recombined with the holes by releasing energy in the form of photon of light.
5. Hence the organic layer emits the light to produce the display.
6. The color of the light depends on the type of organic molecules while the brightness depends on the amount of the current applied.
7. By maximizing the recombination process in the emissive layer the output light can be improved in OLED devices.
8. Thus the emissive layer is slightly doped with highly fluorescent molecules to enhance the electro-luminescent efficiency and control of color.

The conductive layer and emissive layers are made of special organic molecules that are helpful in conducting electricity. Anode and cathode are used for connecting OLEDs to the source of electricity. When power is applied to an OLED, the emissive layer becomes negatively charged and the conductive layer becomes positively charged. Due to electrostatic forces applied, the electrons move from the positive conductive layer to a negative emissive layer. This may lead to a change in electrical levels and creates radiation that varies in frequency range of visible light



Easy Working

1. To make an OLED light up, we simply attach a voltage (potential difference) across the anode and cathode.
2. As the electricity starts to flow, the cathode receives electrons from the power source and the anode loses them
3. Now we have a situation where the added electrons are making the emissive layer negatively charged (similar to the n-type layer in a junction diode), while the conductive layer is becoming positively charged (similar to p-type material).
4. Positive holes are much more mobile than negative electrons so they jump across the boundary from the conductive layer to the emissive layer. When a hole (a lack of electron) meets an electron, the two things cancel out and release a brief burst of

energy in the form of a particle of light—a **photon**, in other words. This process is called **recombination**, and because it's happening many times a second the OLED produces continuous light for as long as the current keeps flowing.

Advantage over conventional display technologies:

- The fabrication process is easy and the display devices are thinner than the conventional display devices.
- Comparing it with the LCD devices, OLED displays can be viewed from different angles as they are "emissive" devices i.e. they emit light rather than modulating transmitted or reflected light.
- They do not use backlight.
- The driving voltage and total power consumption is low as comparing to other display technologies.
- The material used are ecofriendly and do not use lead or other such material.

Graphics Card

The images you see on your monitor are made of tiny dots called pixels. At most common resolution settings, a screen displays over a million pixels, and the computer has to decide what to do with everyone in order to create an image. To do this, it needs a translator which take binary data from the CPU and turn it into a picture you can see. Unless a computer has graphics capability built into the motherboard, that translation takes place on the graphics card. **The graphics card decides how to use the pixels on the screen to create the image. It then sends that information to the monitor through a cable. - Creating an image out of binary data is a demanding process.** The graphics card accomplishes this task using four main components:

- A motherboard connection for data and power
- A processor to decide what to do with each pixel on the screen
- Memory to hold information about each pixel and to temporarily store completed pictures
- A monitor connection so you can see the final result

Working

Processor-A graphics card is a printed circuit board that has a processor and RAM. It also has an input/output system (BIOS) chip, which stores the card's settings and performs diagnostics on the memory, input and output at startup. A graphics card's processor, called a **graphics processing unit** (GPU), is similar to a computer's CPU. A GPU perform complex mathematical and geometric calculations that are necessary for graphics execution. Some of the fastest GPUs have more transistors than the average CPU. A GPU produces a lot of heat, so it is usually located under a heat sink or a fan. accelerated video cards is an internal card installed on PCI,AGP or PCI-E slot.it produce images on the computer screen by using its own processor and memory. It reduces CPU's burden

In addition to its processing power, a GPU uses special programming to help it analyze and use data. **ATI** and **nVidia** produce the vast majority of GPUs on the market, and both companies have developed their own enhancements for GPU performance. To improve image quality, the processors use:

Memory-As the GPU creates images, it needs somewhere to hold information and completed pictures. It uses the card's RAM for this purpose, storing data about each pixel, its color and its location on the screen. Part of the RAM can also act as a **frame buffer**, meaning that it holds completed images until it is time to display them. Typically, video RAM operates at very high speeds and is **dual ported**, meaning that the system can read from it and write to it at the same time.

The RAM connects directly to the digital-to-analog converter, called the DAC. This converter, also called the RAMDAC, translates the image into an analog signal that the monitor can use. Some cards have multiple RAMDACs, which can improve performance and support more than one monitor. The RAMDAC sends the final picture to the monitor through a cable.

Motherboard-Graphics cards connect to the computer through the motherboard. The motherboard supplies power to the card and lets it communicate with the CPU. Newer graphics cards often require more power than the motherboard can provide, so they also have a direct connection to the computer's power supply.

Connections to the motherboard are usually through one of three interfaces:

- Peripheral component interconnect (PCI)-included in all Pentium class computers.it is commonly used for 2D graphics cards, sound cards, network interface cards and other expansion cards that attach directly to the motherboard.PCI card slot is required.it may support a number of different devices.
- Advanced graphics port (AGP)-it is faster than PCI interface.it create high speed link between the video card and PC's processor. Used for 3D graphics
- PCI Express (PCIe)-PCI Express is the newest of the three and provides the fastest transfer rates between the graphics card and the motherboard. PCIe also supports the use of two graphics cards in the same computer.

Most graphics cards have two monitor connections. Often, one is a DVI connector, which supports LCD screens, and the other is a VGA connector, which supports CRT screens. Some graphics cards have two DVI connectors instead. But that doesn't rule out using a CRT screen; CRT screens can connect to DVI ports through an adapter.

Most people use only one of their two monitor connections. People who need to use two monitors can purchase a graphics card with dual head capability, which splits the display between the two screens. A computer with two dual head, PCIe-enabled video cards could theoretically support four monitors.

In addition to connections for the motherboard and monitor, some graphics cards have connections for:

- TV display: TV-out or S-video
- Analog video cameras: ViVo or video in/video out
- Digital cameras: FireWire or USB
- Some cards also incorporate TV tuners.

The graphics card's hardware directly affects its speed. These are the hardware specifications that most affect the card's speed and the units in which they are measured:

- GPU clock speed (MHz)

- Size of the memory bus (bits)
- Amount of available memory (MB)
- Memory clock rate (MHz)
- Memory bandwidth (GB/s)
- RAMDAC speed (MHz)

Video Card Standards-

Monochrome display Adapter- Earlier Pc's did not have graphics.IBM PC and PC XT uses monochrome display adapter that display only text.it is a one color monitor.

Monochrome Graphics Adapter-MGA combined graphics and text both.PC graphics started from MGA adapters.

Color Graphics Adapter-

- IBM developed CGA.
- It has more graphics capability than MGA.
- It can display up to 16 colors.
- Screen resolution is 640X200.
- It has 16KB of video memory

EGA-

- Also developed by IBM
- Enhanced Graphics Adapter-
- Screen resolution is increased in EGA 640X350.
- Support up to 64 colors.
- Supported 64KB of video memory

VGA-

- Video Graphics Array-
- Support up to 256 colors.
- Resolution is increased 640X480.
- It is supported by many PC manufacturers.
- Backward compatible with CGA and EGA

SVGA-

- Super video Graphics Array is developed by VESA(Video Electronics Graphics Array).
- It include all video graphics standards.
- It has better resolution or more colors than VGA.
- It support 16 million colors.
- It has range of resolutions (800X600,1024X768,1280X1024,1600X1200 and higher).
- It is a popular graphics card adapter.