**Electronic Paper**

Electronic Paper also known as e-paper is a term for display technologies resembling a paper. The popularity of the display is due to its contrast, thickness, readability and flexibility.

E Ink is now one of the popular e-paper display technologies. It was developed by E Ink Corporation and today they are used by different companies in their products and e-readers. E Ink displays are made of some tiny capsules which consist of black and white particles. With the help of electricity either the black or white particles rise up towards the capsule and thereby change the color of the pixel. In order to make an e-ink display, first the ink is printed to a sheet made of plastic which acts as the front plane of the e-ink display. The plastic sheets are thereafter laminated onto the active matrix backplanes forming the e-ink display. To control the pattern of the pixels in the display, controllers and integrated circuits are added.

**LED Display**

This is a type of display that uses light emitting diodes (LED is short for Light Emitting Diode).

An LED emits light as a result of electric luminescence. It is also known as “cold light” as, unlike with old-fashioned incandescent bulbs (the ones with the heated tungsten wire), the light is not produced by heating a metal filament. The diode, on the other hand, emits light when flowing through two specially coated silicon semiconductors. It is one of the most energy-efficient and power-saving ways to produce light. This is why today almost all smartphones use some variant of the LED display.

An LED consists of solid materials without moving parts and is often moulded into transparent plastic. This ensures high durability. When an LED is on, it emits almost zero heat. This reduces the problem of cooling the electronic parts.

The first LED was created by Russian inventor Oleg Losev in 1927. For many years, it was only possible to produce infrared, red and yellow LEDs. These diodes were found in everything from remote controls to clock radios (fun fact the LED in your TV remote control is an infrared LED).

It was not until 1994 that Japanese scientist Shuji Nakamura was able to demonstrate an efficient blue LED. White and green LEDs soon followed, laying the foundation for the LED revolution we have seen in lighting and display technology.

**Liquid Crystal Display (LCD)**

This display generally depends upon the light modulating properties of liquid crystals. It also has low power consumption, although not as low as an LED display, and that is why they are used less and less in portable devices. They are usually cheaper and that’s why they are still used in lower budget monitors laptops and TVs. LCDs are electronically modulated and are made of liquid crystals which are arrayed in front of the light source to produce images in color.

An LCD screen has a white backlight which shines constantly no matter what has to be displayed on the screen. The light produced is polarized by a filter and after that it goes through the liquid crystal matrix. The liquid crystal in each pixel in the matrix can be polarized by applying voltage and depending on the amount of polarization a different amount of light emitted from the backlight is allowed to pass through. There are also red, green and blue filters for the primary colors.

The lower efficiency of the LCD in comparison to the LED displays is mainly due to the fact that even if a completely back image is displayed on the screen, the LDC’s backlight still shines (and the light is blocked by the liquid crystal layer). On the other hand an LED display just turns off all its pixels.

**Cathode-ray tube (CRT)**

A cathode-ray tube (CRT) is a vacuum tube containing one or more electron guns, which emit electron beams that are manipulated to display images on a screen. A CRT on a television set is commonly called a picture tube. The term cathode ray was used to describe electron beams when they were first discovered, before it was understood that what was emitted from the cathode was a beam of electrons. The big, bulky, old TVs you may remember use this technology.

A CRT is a glass envelope which is deep (i.e., long from front screen face to rear end), heavy, and fragile. The interior is evacuated to nearly a complete vacuum to facilitate the free flight of electrons from the gun(s) to the tube's face without scattering due to collisions with air molecules. At the rear of the tube there is a cathode, which is heated by a tungsten coil, causing it to emit electrons. These electrons are focused into a beam by focusing coils, the electron beam is steered by deflection coils and an anode accelerates the beam towards the screen. The screen is coated with phosphorus and it generates light when hit by the electrons. In color devices there are 3 electron beams, one for each primary color (red, green and blue) and an image is produced by controlling the intensity of each of the 3 electron beams.

To display an image, the entire screen is scanned around 30 to 60 times per second in a fixed pattern called a raster. The scanning usually is done from left to right row by row or every other row. Interestingly at any given moment only very few pixels are actually emitting light. The reason we see a complete image is because of the persistence of vision of the human eye.

Fun fact: the speed at which the electron beam moves across the screen is about 10 to 20 km\s depending on the size and resolution of the screen.