The comparison between the CRT monitor with 3 new types of monitors: LCD, PDP and OLED

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Abstract. Display/monitor plays an important role in the daily lives. With the development of science and technology, more and more types of displays appear with a variety of applications. One of the earliest displays, the CRT display, served as the catalyst for the development of the display sector. It could still bee seen occasionally now even more than a century after it was created. The development of more sophisticated displays, including LCD, PDP, and OLED displays, is ongoing. They are all irreplaceable for various reasons, and each has its own special benefits. They exhibit better performances than CRTS. The purpose of this work is to compare the working principle, performances, advantages, disadvantages, application, and novel developments of the above four kinds of displays. In the process of summarizing the characteristics of these display materials, their future development trend can be predicted and summarized. Based on their design flaws, they can also be combined to find their improvement direction.

Keywords: Display, CRT, OLED, PDP, LCD

1. Introduction

Monitors are an indispensable item in this day and age, permeating every aspect of people's daily lives, whether it is essential mobile phones or medical devices that help diagnose a patient's condition. Moreover, the screen is humans' most intuitive feeling about mobile phones and computers. The quality of the screen directly affects how that look, operates smoothly and sees.

Cathode-ray tube (CRT) is one of the most widely used monitors. An electron beam striking a phosphorescent surface in a specialized vacuum tube causes pictures to be generated. The price is cheaper than other displays, short response time, large visual Angle, no bad points, high color reduction, color uniformity, adjustable multi-resolution mode, and other advantages [1]. Because of the large volume, high radiation, and high power consumption, the market has gradually eliminated, only on some specific occasions use it. At the same time, Liquid Crystal Display (LCD), Plasma Display Pane (PDP), and organic light-emitting diode (OLED) began to replace it, because their combined performance is more powerful than that of CRT [2]. Each of them has outstanding advantages, but there are also obvious problems. Therefore, the future goal is to summarize the advantages and disadvantages of these displays to develop a display with a more powerful comprehensive performance.

The following sections will introduce and analyze the four different displays mentioned above, summarize their advantages and disadvantages, and predict the future development direction of the display.

2. A comprehensive evaluation of the CRT

2.1. The working principle of CRT

The CRT monitor is a kind of using a Cathode Ray Tube monitor. The electron gun created a beam of electrons. The anodes accelerate the electrons [1]. The electromagnetic field created by deflecting coils, which is extremely low frequency, enables the electron beam's direction to be changed continuously. The deflecting coils come in two different sets: horizontal and vertical. (For simplicity, there is only one set of coils in the illustration.) The beam's intensity may be adjusted. When the electron beam hits the phosphor-coated screen, it leaves a tiny, brilliant visible spot. Since the

phosphor on the inner surface of the screen will quickly extinguish when it is lighted, the electron beam used in CRT displays must continually cycle between these dots in order to display the image.

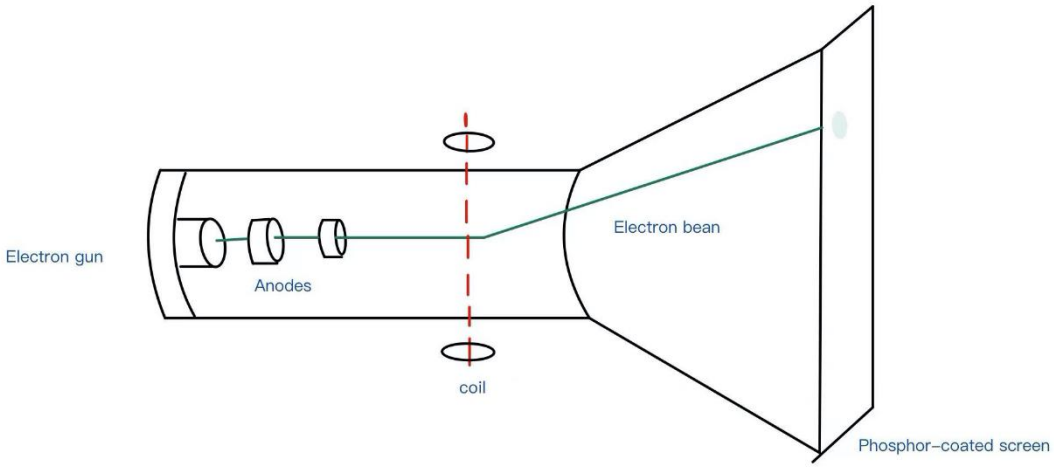

Figure 1. The working principle of CRT

First of all, on a fluorescent screen covered with a certain arrangement of closely spaced red, green, and blue phosphor dots or bars, known as phosphor units, each neighboring red, green, and blue phosphor unit makes up a group that is known by the scientific term of a pixel. Red, green, and blue are the three main hues used in each pixel (R, G, B).

The three fundamental colors are controlled and expressed via a CRT monitor using an electron beam. The cathode emits electrons when the cathode is heated by the filament, which causes the electrode to accelerate. By concentrating the electrode into a very narrow electron beam under the influence of high pressure, the anode receives enormous energy and has extremely high efficiency. For this reason, the electron gun emits not one beam, but three beams, they are controlled by the computer graphics card R, G, and B three primary color video signal voltages, to bombard the respective phosphor unit [1]. By the excitation of the high-speed electron beam, these phosphor units are issued by the different intensities of red, green, and blue three kinds of light. The spatial mixing method, which mixes the three primary colors of light by shining them on three points near the same surface at the same time to create rich colors, uses the fact that people's eyes lose their high resolution after a certain distance to produce the same results as the direct color mixing method. With this technique, it is possible to create pixels of various colors, and a great deal of these pixels may be combined to create a stunning image, which can then be moved about.

2.2. The development and application of CRT

CRT monitors, like other hardware devices, often break down. Due to the high voltage, it is dangerous to repair or maintain, and it needs expert convergence calibration and modifications for changes in geographic position. If handled poorly, a glass display tube that is evacuated runs the danger of imploding. However, the survey found that only about 20% of the failures were really due to poor quality or natural damage, and most of the failures were due to poor environmental conditions and improper operation or mismanagement. It can be seen that environmental conditions and human factors are the main causes of monitor failure [3].

In the vast majority of situations, LCD displays that are tiny, low-power, and inexpensive have taken the place of CRT monitors, except for a few unique occasions.

While CRT monitors have been largely replaced by LCD displays as the industry standard for computer installations, certain industries that have stringent color-reproduction requirements, such as metallurgy and medicine, still require the use of CRT monitors for operations [4].

For example, in the field of vision research, CRT monitors are considered to be the most suitable visual stimulator at present due to their advantages such as large visual Angle and short response time.

However, CRT monitor manufacturers began reducing and eventually discontinued their production more than a decade ago, and there are now so few CRT monitors on the market that most vision research has to rely on older, unstable CRT monitors [4].

3. A comprehensive evaluation of LCD

3.1. The working principle of LCD

An LCD (Liquid Crystal Display) is a kind of flat panel display that operates primarily using liquid crystals. Given that they are often used in cellphones, televisions, computers, and instrument panels, LEDs offer a wide range of applications for consumers and enterprises.

A unique direct-viewing image display technology called the Plasma Display Pane uses a liquid crystal panel in addition to a cathode ray tube. Plasma display with outstanding image effect, unique digital signal direct drive and become excellent video display equipment and high-definition computer display, it will be the best display screen of high-definition digital TV [5].

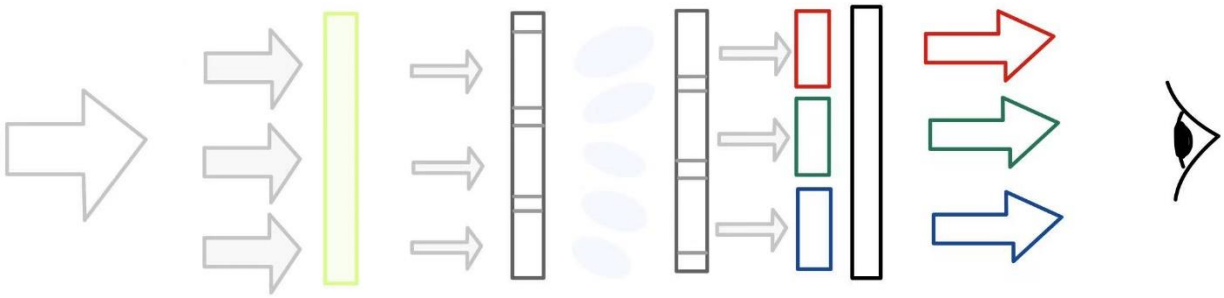

Figure 2. The working principle of LCD

The light from the backlight plate enters the liquid crystal layer, which has thousands of liquid crystal droplets, after passing through the first layer of the polarization filter and the backlight plate. One or more of the tiny cells that hold the droplets in the liquid crystal layer combine to form a pixel on the screen. There is a transparent electrode that is divided into rows and columns between the glass plate and the liquid crystal substance. The optical rotation state of the liquid crystal is altered by varying the voltage at the intersection of the rows and columns. The liquid crystal substance performs the function of a tiny light valve. The driving circuit and the control circuit are located around the liquid crystal material. The liquid crystal molecules in the LCD distort when an electric field is created by the electrodes, refracting the light that normally passes through them. This refracted light is then filtered through a second filter layer and shown on the screen.

3.2. The development and application of LCD

It was at the end of the 19th century that Austrian botanists discovered liquid crystals, i.e. crystals in liquid form, meaning that a substance has both the fluidity of a liquid and some crystalline-like arrangement properties. The arrangement of the liquid crystal molecules varies in the presence of an electric field. The electro-optical effect, a phenomena that change its optical characteristics, results from this. The first liquid crystal displays, or LCDs, were created by British scientists in this century as a result of the electro-optical effect of liquid crystals. Today's LCDs are extensively used as fixed-line liquid crystals, which, when seen in detail, resemble cotton swabs. Compared with the traditional CRT, LCDs are not only small, thin (currently 14.1 inches thick, only 5 cm), light, low energy consumption (1 to 10 microwatts/cm2), low operating voltage (1.5 to 6 V) and no radiation, flicker-

free and can be directly matched to CMOS integrated circuits. Due to the many advantages, LCDs have been used in desktop applications since 1998 [6].

There are many advantages of LCD, First of all, the LCD's white color display is quite delicate, no stroboscopic and can be used continuously without damaging the eyes. Then, long life, and ease of color. It belongs to low power consumption products and can be completely not hot, relative to CRT display because the development technology inevitably produces high temperature. With high precision picture quality. Because of its principle problem, there will not be any geometric distortion, or linear distortion, and will not be caused by a lack of power supply screen color distortion. Also, the viewing angle of a CRT monitor is the maximum angle at which all contents on the screen can be clearly seen from different directions [6]. The viewing Angle of a CRT monitor can theoretically be close to 180 degrees up/down/right/left. Because LCD uses light transmission to develop images, so the viewing Angle of LCD is smaller than that of a CRT display. In an LCD, both direct and oblique light penetrate the pixels in the same display area, so when viewing the screen from a larger Angle than the viewable Angle, the image will be found to be double and discolored [7].

At present, the horizontal (left and right) viewing Angle of the liquid crystal display on the market is generally above 120 degrees, and the vertical (up and down) viewing Angle is slightly smaller, generally above 100 degrees. In order to get a better viewing Angle in use, in addition to adjusting the sitting position or monitor Angle to try to face the LCD, you can adjust the brightness of the LCD appropriately, which can also make the LCD available viewing Angle to maximize the play.

Finally, there is the thin body, which saves space compared to the bulky CRT monitors. LCD takes up a third of the space.

But, the disadvantages of LCD are obvious too. First of all, the LCD cannot be completely closed, so when the LCD displays black, part of the light will pass through the color layer, so the black of the LCD is actually gray mixed with white and black, which causes a certain degree of power consumption. Second, it is thicker than OLED due to the presence of the backlight layer and liquid crystal layer, making it cumbersome to make a phone. It's also hard to bend [4].

LCD technology has become a crucial display technology because it is the only one that can display both the straightforward time information of a digital wristwatch and the intricate color graphics of computers and televisions. The complex and diverse subject of liquid crystal displays and liquid crystal materials requires an interdisciplinary research strategy encompassing physics, chemistry, and display technology [5].

4. A comprehensive evaluation of the PDP

4.1. The working principle of PDP

Plasma Display Panel (PDP) is a novel direct-viewing image Display device. Plasma display has become an excellent video display device and a high-definition computer display because of its outstanding image effect and unique digital signal direct drive.

It uses a plasma tube as a light emitting element, each plasma tube on the screen corresponds to a pixel, the screen as a glass substrate, substrate spacing a certain distance, surrounded by an airtight seal to form a discharge space. The discharge space is filled with neon, xenon, and other inert gases as the working medium. As an excitation electrode, a metal oxide conductive film is coated on the inner surface of two glass substrates. When a voltage is added to the electrode, the mixed gas in the discharge space will produce a plasma discharge phenomenon. The fluorescent screen is excited by the ultraviolet light produced by the gas plasma discharge, and the fluorescent screen then emits visible light to display the picture.

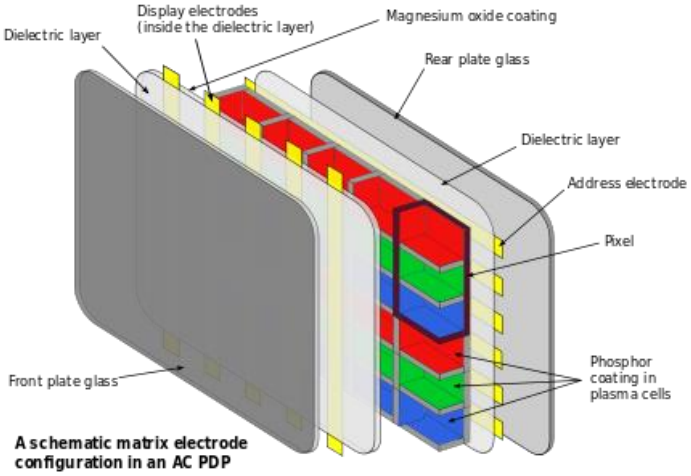

Figure 3. The working principle of PDP [8]

There are 3-type of PDP: AC DC and SM [9].

The principle of the DCPDP is that the discharge gas is in direct contact with the electrode and the electrode is connected in series with a resistor for current limiting, the light is located on the surface of the cathode and is continuous with the voltage waveform.

The principle of ACPDP is that the discharge gas is isolated from the electrodes by a transparent dielectric layer, the isolation layer is a series capacitor for current limiting purposes, and the discharge is driven by the capacitor's isolation through the crossover effect and needs to be driven by alternating pulse voltage, for this reason, there is no fixed cathode and anode, the light is located on the surface of the two electrodes, and is alternately pulsed light.

The principle of the SM-PDP is to replace the traditional insulating media barrier with a metal cover. It has the advantages of a simple production process, easy to achieve mass production, low discharge voltage, high brightness, and fast response frequency.

4.2. The properties of PDP

Pictures of different displays are shown, ranging from the first single-pixel device developed at the University of Illinois in 1964 to the 80-inch diagonal full-color high-definition televisions now available in department shops. Over the span of the plasma display panel's 40-year evolution, these displays were created. Important concepts and advances utilized in modern plasma TV devices are studied in terms of the physical and electrical principles used [10].

PDP displays are smaller, lighter, and free of X-ray radiation than color TVs with direct vision tubes. In addition, because the structure of each luminescent unit of PDP is the same, the common image geometric distortion of the picture tube will not occur. The PDP screen brightness is very uniform - there are no bright and dark areas, unlike the brightness of the picture tube - the center of the screen is slightly brighter than the surrounding areas, and the PDP is not affected by magnetic fields, so it is better adapted to the environment. Compared with LCD, PDP display has the advantages of high brightness, good color reduction, rich gray level, and fast response to rapidly changing pictures.

Additionally, the PDP plasma display's unique construction has several drawbacks. For example, since the plasma display has a flat design and the glass on the display is incredibly thin, its surface can't handle too much or too little air pressure, let alone unexpected forces. Each pixel of a PDP display emits its own light independently, which consumes a lot more power than a tube television using an electron gun. General plasma display power consumption is higher than 300 watts, is the future household appliances in the real power consumption. Because of the high heat output, the PDP display backplane is equipped with multiple groups of fans for heat dissipation. In addition, the price

of PDP is relatively high, and it is mainly used in public places, such as airports, railway stations, exhibition halls, corporate seminars, academic conferences, and remote conferences.

5. A comprehensive evaluation of the OLED

5.1. The working principle of the OLED

An organic light-emitting diode (OLED), often referred to as an organic electroluminescent (organic EL) diode, is a light-emitting diode (LED) in which the emissive electroluminescent layer is a film of an organic compound that produces light in response to an electric current. This organic layer is sandwiched between two electrodes, usually with at least one transparent electrode. OLEDs are utilized to make digital displays in gadgets like televisions, computer monitors, and portable gaming systems like smartphones. The creation of white OLED components for use in solid-state lighting applications is a significant area of research [11].

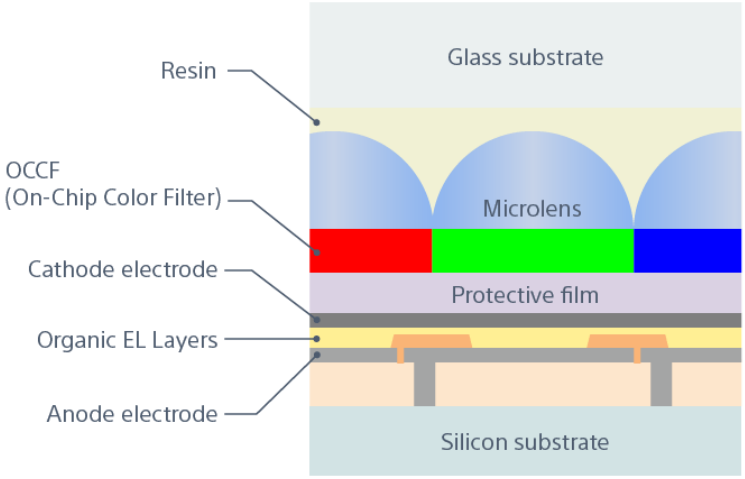

Figure 4. The principle of the OLED [13]

The current kind of organic light-emitting devices are OLEDs. Carrier injection and recombination cause the luminescence phenomenon. The luminescence intensity is linearly influenced by the injected current. Under the influence of the electric field, the hole and electron created by the anode and cathode of the OLED will move, inject into the hole transport layer and the electron transport layer, and migrate to the luminous layer. When the two interact in the luminescent layer, energy excitons are produced, which excite the luminescent molecules and ultimately lead to the creation of visible light [12].

5.2. The property of OLED

Organic light-emitting diodes (OLEDs) have been regarded as one of the most promising technologies for upcoming displays since Kodak made a breakthrough in this field in 1987. To meet this application's requirements, various materials have been created and upgraded [13].

OLED offers the benefits of vivid colors and little power usage. Its display technology is self-lighting; a very thin layer of organic materials is applied to a glass substrate, and when current flows through it, these organic materials emit light. As a result, not only is the display angle large, but power consumption is also decreased because there is no LED backlight [14].

Additionally, OLED displays black color by shutting off pixels in the dark region to provide a nearly pure black color while also using less power. Another big feature is that it can be bent in the design of screen applications, so it can be used for a wider range of designs, such as curved screens, fingerprint identification under the screen, etc [15].

But at the same time, it has disadvantages: compared to other displays, their lifespan is lower since they are constructed of organic material, because they don't shine brightly, using them in direct

sunlight is difficult, in comparison to other displays, the OLED production process is quite expensive, they are more susceptible to water damage and moisture damage [14].

6. Conclusion

To conclude, the CRT monitor has no obvious advantages compared with the other new-type monitors since it has problems with Volume, weight, energy consumption, and environmental protection. But it hasn't been completely phased out, and there are still places where it's needed.

Nowadays, although the technology of CRT display has not changed essentially, some improved technology has been gradually integrated into its design. We have reason to believe that the technology of CRT display will continue to develop as long as it does not replace completely and people's innovative spirit remains unchanged.

LCD is one of the mainstream display screen types at present because its color is very soft, will not harm the eyes, more advanced than CRT, in the refresh frequency, color number, and visual Angle, its advanced sense is very obvious. However, compared with OLED, it also uses energy and is not prone to zigzag problems.

PDP is also one of the high-end displays on the market at present, compared with CRT, it is smaller in size, light in weight, has no X-ray radiation, is smart, and its image will not produce distortion. The images are clear, the colors are bright, and the feeling is more comfortable. It's also brighter, more reductive, and has a larger viewing angle than LCDs. However, it also has the disadvantages of high cost and power consumption.

OLED is by far the most commonly used display for mobile phones. Its advantages are obvious, high brightness, fast reaction time, simple production process, can be bent, etc. At the same time, it is not perfect, but also has a short life, flash screen, and high-cost shortcomings.

From the beginning of CRT display to the current LCD, PDP, and OLED display, have made a lot of progress. While there have been some performance improvements, there have also been some issues. We can realize that no matter how developed the current display is, there are still some scenes that need CRT display, it has irreplaceable. And the other three kinds of the display are the same, although their problems have not been solved, they can not be completely eliminated, which leads to the waste of some resources, if there are more perfect display materials, and make they are obsolete, maybe the development direction of the future display. Scientists are already looking for near-perfect materials, such as graphene, which is being investigated.

There is no doubt that the current display is in the direction of energy saving, low cost, lightweight, thin, standardized development.

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