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Thin-film Transistor Technology

Abstract

Thin Film Transistor (TFT) is a special kind the transistor which is certainly different from the conventional transistors by depositing the semiconductor or silicon. It is highly used in LCD that is leading one in the area of flat panel display technology. In this technology the transistors are having the current carrying layers of thin film. So in this fashion transistors are fabricated by the semiconductors and called thin film transistor. In this paper we will see the comparative study of the thin film or active matrix with passive matrix, CRT as well as I through the light on quality, features and functionalities of TFT along with the maintenance.

Introduction

A typical home or office desk with a computer system, in all probability will be having CRT monitor. CRT monitors have been around for a long time, they give clear display and are easily available at affordable prices, have good operational life and provide every thing that one would want from a monitor. TFT display provides many benefits that you may want to see and may replace your existing CRT monitor with a TFT monitor.

A CRT monitor uses an electron gun to bombard electrons over a glass tube coated with phosphor, which glows when struck by the electron beam. This setup makes CRT bulky and big in size. On the other hand, TFT displays, which are active-matrix LCDs, use liquid crystal sandwiched between thin polarized sheets for

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the display. The pixels on the screen are controlled electrically using transistors.

This architecture of TFT provides it many advantages over a CRT.TFT displays are much thinner that CRT and thus save valuable desk space. Not only thinner, they are lighter than CRTs, hence are more portable. Large TFT displays can be hanged on a wall to make presentations. They can easily be shifted from one place to another. Also with pivot, tilt, swivel options TFT monitors are more usable than a CRT and can be used in a much wider range of applications.

Not only benefits of weight and size, a TFT offers much more. TFT technology is less emissive than the CRT, hence makes for more restful viewing over a long time and causes less eye strain. In a CRT, the electron gun has to scan the tube surface from top to bottom and again, which some times lead to flickering. But in a TFT, each pixel is individually controlled, eliminating any chances of flickering. The TFT technology has evolved to a great extend and provide excellent playback for DVD-video. Many high definition TV displays from various vendors are using TFT technology as it provides minimum blurring, less distortion and equivalent brightness as a CRT.

All these benefits? Then why doesn't everybody use a TFT instead of the CRT. Price plays a major role when choosing between TFT and CRT. While CRT displays are cheaper that TFT, considering all the benefits of TFT and CRT. While CRT displays are cheaper that TFT, considering all the benefits of TFT, opting for it can be good proposition. A TFT consumes about 1/3 of the power consumed by CRT, so for businesses it brings price advantage over a long time. Being lighter, transportation costs are also lower for TFT. Last but not the least TFT is a thing of beauty with slim, smart looks. As against the bulky CRT, TFT monitors are objects of desire.

Thin-film transistor

Liquid crystals were first discovered in the late 19th century and were found to be almost transparent substances that exhibited the properties of both solid as well as liquid matter. When light passes through liquid crystals, it follows the alignment of the molecules that make them up, which is a property of solids. Consequently it was discovered that passing electricity through liquid crystals changed their molecular alignments, thus the light passing through them as well – a property of liquids. These are the two main properties that are harnessed in LCD displays.

LCD principles

LCD is a transmissive technology. This means that the display works by letting through varying amounts of light from a permanent backlight. Colors are achieved by selective filtering of white light. Two polarize filters, color filters and two alignment layers determine exactly how much light is allowed to pass and which colors are created. The layers are positioned between two glass panels.

Natural light waves are oriented at random angles. A polarizing filter is simply a set of incredibly fine parallel lines. These lines act like a net, blocking all light waves lines. Two polarizing filters are oriented perpendicular to each other, so that in their default mode they will not let any light through. However, the crystals in between these filters are made in such a way that they twist the light

perpendicularly as it passes through then, thus letting it pass through the second filter. However, when a voltage is applied to these crystals, they line up in a straight manner and no longer twist the light, thus making that region dark. This basic principle is used on a pixel-by-pixel basis to make the whole display work.

The crystals in an LCD can alternatively be arranged in such a manner that light passes through them only when voltage is applied, but this is not done because computer display are mostly lit up. Hence, power is saved by letting through the light when there is no voltage.

TFT Vs Passive Matrix

Many companies have adopted Thin Film Transistor (TFT) technology to improve colour screens. In a TFT screen, also known as active matrix, an extra matrix of transistors is connected to the LCD panel- one transistor for each colour (RGB) of each pixel. These transistors drive the pixels, eliminating at a stroke the problems of ghosting and slow response speeds that afflict non-TFT LCDs. Ghosting is an effect in which an area of 'on' pixels causes a shadow on 'off' pixels in the same rows and columns.

Comparative study of LCDs and traditional CRTs

TFT displays have some very good characteristics compared to traditional CRTs. For example-

1. LCDs are usually much brighter than CRTs, since they use just one simple backlight. There brightness can be roughly 170-250 cd/sq.m. compared to 80-120 cd/sq.m. for CRTs.

2. They tend to have a lower contrast ratio.

3. Focus and convergence errors are almost non-existent on LCDs and they have perfect geometry. A CRT has three electron guns whose streams must converge faultlessly in order to create a sharp image. There are no convergence problems with an LCD panel because each cell is switched on and off individually. Also, since there is not electron gun scanning the picture on the monitor, there is no flicker.

4. Power consumption is something on which LCD displays score quite a few points on CRTs. Typical power usage is 25-40W compared to 60-150W of CRTs.

5. Unlike CRT monitors, the diagonal measurement of an LCD is the same as its viewable area, so behind the monitor's faceplate or bezel. The combination makes any LCD a match for a CRT 2 to 3 inches larger:

   On the other side, the angle at which LCDs can be viewed also differs rapidly from 50 to 180 degrees. While this can provide a little privacy for laptop users, it is generally considered to be a weakness of LCD displays.

TFT monitor Provide features

They're available in different sizes, features and even have some technical difference. Screen size for instance, can range from 15" all the way to 40". Features could be a simple TFT for regular work to one that has a built-in TV tuner with remote control, supporting multiple video formats like PAL/NTSC/SECAM, etc. its important therefore, to know these differences to make a more informed

purchase decision for the same. Basically, the factors to look into can be divided into two – performance and features.

Quality matters

Even though TFT monitors consume less power than CRT monitors, you may still want to check out how much it is between different models. It can vary, and would become very important if you're buying in large volumes. The maximum supported resolution and refresh rate are also important. Ideally, if you're buying for the desktop, then it should support at least 1024 x 768 with a refresh rate of at least 72 Hz. You may also want to check the image clarity at these different resolutions.

From that we move to display quality and viewing angle which is an important parameter there. This is the maximum angle from which you can view the TFT display without any deterioration in display quality. Here, you need to check for both the horizontal and vertical viewing angles. Typical viewing angles are 130 deg horizontal and 95 degrees vertical, but you can also find monitors supporting higher or lower angles. The higher the angle obviously the better.

You need to physically adjust the monitor to suit your comfort. So, it becomes important to check the monitor's tilt, swivel and height adjustment capabilities. Ensure that it's not very difficult to slide the monitor in various directions. There are monitors that don't let you do some of these movements at all, so check this out before buying.

Another desirable feature in TFT monitors is automatic picture adjustment. You might have noticed in CRT monitors that when you switch to a different refresh rate, the picture you see on the screen moves out of the viewing area. This can be quite irritating as you would again have to toil with the settings to bring the picture back in place. Check that your TFT monitor offers automatic picture adjustment.

Lastly, you might just like to measure the monitor's viewing area to see whether it's actually the claimed size. This is the diagonal length from one top corner of the monitor to the bottom. Some monitors might have a coating around the border, which actually reduces the viewable area. In case a monitor comes with speakers, you could check whether they're stereo or mono (stereo preferred), whether the sound is good enough, whether the maximum volume suits your needs and it doesn't split.

Features and functionality

There are lots of other things to consider in a TFT monitor, which would decide what they would be used for. The kind of viewing supported for instance is important. There are TFT monitors that let you rotate the display round by 90 degrees so that the picture appears in portrait mode also. This feature can be useful when you're working with long documents. Currently the numbers of models that support this feature is limited. Another piece of software can be for automatic screen adjustment. We talked about this feature earlier in the article. This would help in case you don't want to fiddle with the OSD controls.

Speaking of controls, check that the OSD controls are easy to use, quick to learn and the keys are not flimsy. Another feature is the ability to lock these controls to that nobody else can fiddle with your settings. If you're buying a monitor for design work, then ensure that it has color

temperature settings. Also, if you want a clearer display, you might want to check whether the monitors has a digital input in addition to the regular analog that connects to most display cards. You would also need a graphics card that supports a digital interface to use this of course.

Other features to look for can be whether the monitor can be wall mounted, in case you want to use it as a display for corporate presentations or in kiosks. Check the bezel size in case you plan to put it on a cramped desktop. Some monitors come with extra features like a USB hub to extend you USB ports from behind your PC, so that they're more easily reachable.

On the higher end of the spectrum, you'll find LCD monitors that can act either as a TV or PC monitor. The TV models would have built-in speakers, and will have a remote control. They'll support multiple video inputs and even be able to work with different video formats like PAL, NTSC and SECAM.

Different viewing angle technologies

LCD displays have a limited viewing angle. They lose contrast and become hard to read at some viewing angles, and just the opposite at others. The size of the viewing angle is determined by several factors, primarily the type of LCD fluid and the duty cycle. Also, quick scene changes like game-play or movies can lead to distorted or streaked images because of the low response times. A few technologies have been introduced that deal with this – like TN + Film, IPS and MVA.

TN+Film

TN+Film is the easiest solution to implement. Like standard TFTs, the liquid crystals are aligned perpendicular to the substrate, and a film on the upper surface increases the viewing angle from about 90 degrees to 140 degrees. However, TN (Twisted nematic) + Film still suffer from the problem of contrast ratio and slow response times.

IPS (IN-plane Switching) or Super TFT)

This technology primarily differs from TN+Film in the way that the liquid crystals are aligned parallel to the substrate, however, the primary disadvantage of this technology is that the electrodes cannot be located on both glass surface as with the TN+Film. Instead, they must be implemented in acomb-like style on the lower glass substrate. This leads to a reduction in contrast because of which a much stronger backlight must be used. Overall, the contrast and brightness don't really improve, but the viewing angle can go up all the way to 170 degrees.

MVA (Multi-domain Vertical Alignment)

Fujitsu has come up with another technology that seems to have the best compromise between contrast, viewing angle and brightness. Called MVA, it attains viewing angles of about 160 degrees, but maintains brightness and contrast.

In MVA, the liquid crystal molecules are not completely vertical in their static state due to protrusions. When an electric field is created by applying a voltage, the crystals get horizontally aligned and the light can now pass through the various layers.

When buying an LCD, it is important that you try it out by actually powering it on and watching it for a while. Viewing angle,

contrast and brightness are all factors that you can decide upon only after seeing the LCD in actual action. Always try to check the LCD with the widest viewing angle. TN+Film being one of the easiest technologies to implement costs the least and gives better yields to the manufacturer. However, it is expected that their market share will decline with time because of technical demerits. IPS can already claim a high market share thanks to several high profiles manufactures like Hitachi and NEC adopting the technology. MVA's market share is improving, and we might get to see a lot more of it in the future.

Digital video signals for TFT displays

Traditional CRT and analog TFT displays work on an analog view signal, so digital signals generated in the graphics board are converted into analog for transmission and display. These displays use the standard analog 15-pin VGA interface, found in all display cards. But analog TFT displays suffer from an unpleasant effect of pixel jitter, caused by synchronization differences between the clock and phase of an analog signal.

Latest TFT displays can work with digital video signals also, so there is no need for digital to analog conversion. These TFT displays require a separate video interface to the graphics board. This digital interface is called DVI (Digital Visual Interface). Several graphics card manufactures are now putting the clock and phase of an analog signal.

Latest TFT displays can work with digital video signals also, so there is no need for digital to analog conversion. These TFT displays require a separate video interface to the graphics board. This digital interface is called DVI (Digital Visual Interface). Several graphics card manufactures are now putting both VGA as well as DVI interface on their cards, but on-board displays still come only with a VGA connector. A VGA to DVI connector can be used in such case, but here the signal is first converted from digital to analog for transmission and then from analog to digital inside the display. This D-A and then A-D conversion leads to loss in signal quality. In addition, for all this conversion, additional hardware is required, which increases the cost of displays. To spare you of buying a VGA to DVI connector, some digital TFT displays also come with a VGA connector.

The DVI specification, created by the Digital Display Working Group, also has some subtleties to it than it seems. It includes three different configurations to accommodate both digital and analog signals within a singe connector. DVI-A (analog) handles analog signals and uses 4 pins. DVI-I(interleave) can handle both analog and digital signals and contains 24+4 pins. Digital TFT displays come with either DVI-D or DVI-I or both but DVI-A is rare.

The next time you feel that your digital TFT is not giving you proper display, try changing your video signal from analog to digital.

LCD care and maintenance

Cleaning

LCDs tend to get smudged. There are many cleaning solutions sold specifically as LCD cleaners. You can use these to clean LCD screens. If you do not use one of these products designated specifically as an LCD cleanser, use isopropyl alcohol (IPA), which you can find in the grocery

store, or water (preferably filtered). Do not use any of the following chemicals or any solutions that contain them: acetone, ethyl alcohol, toluene, ethyl acid, ammonia, or methyl chloride. If you have a different chemical or solution and are not sure whether it is suitable, do not use it. Using any of the chemicals in the previous list may cause permanent damage to the LCD.

To clean the LCD display, use a soft, clean cloth (such as a lens cloth used to clean eyeglasses). Moisten the cloth with the cleaner, and then stroke the cloth across the display in one direction, moving from the top of the display to the bottom.

Maintenance

Take the following precautions when using and storing your LCD screen:

1. Avoid subjecting your LCD to extremes of temperature and humidity.
2. Avoid long-term storage in locations that receive direct sunlight or fluorescent light.
3. Hard physical shocks to LCD.
4. Do not scratch, twist or hit the surface of the LCD screen.
5. Although a screen saver can be used, it keeps the display backlight in use thereby decreasing its overall life. Putting the computer to sleep or shutting it won't be used for extended periods is preferred to using a screen saver.
6. An image can be burned into an LCD panel if left displayed for an extended period (approximately 24 hours, depending on the image and LCD). However, unlike monitors with a cathode-ray tube (CRT), an LCD panel recovers over time and eventually dissipates the image. To allow this recovery, the display panel must be turned off. The time it takes to recover depends on the original image and how long it was left on the screen. It generally takes between one and two times as long to remove the image as it took to burn it in. In other words, if you're going to leave your computer on, make sure it's set to put the display to sleep after a hour or so.

Future display technology

Even as regular 15" to 17" TFT LCD monitors make inroads into the PC desktop market, there's a lot of action on to improve the technology and take it much beyond that. Already, LCD monitors are available in screen sizes as large as 40". At the other extreme, some of these monitors are small enough to fit behind your car's headrest, sunvisor or ceiling. But size variations are not all. Besides these, developments are on to improve their display quality, increase the resolution and also search for better material for manufacturing.

Display in thin air

The latest in display technologies is the recently announced heliodisplay, which projects video into thin air. It creates an image that is 27' in size and interactive. Meaning, you could use a hand or a finger to manipulate the image. Basically, it changes the properties of air in a localized environment. While this has been developed at the Massachusetts Institute of Technology, another similar display has been developed in Finland, which projects

images onto a cloud of water vapor diffused into air.

Folding displays

Another interesting development in display technology is the new FOLED (FLEXIBLE organic Light emitting Device) based displays. These will allow displays to be built on flexible material such as plastic films or metal foils. The flexible material will have the advantage that it can be fit even on a curved surface. So who knows, maybe one day soon, you'll be able to fold your display screen and keep it in your pocket.

Conclusions

Based on the study on the TFT we have presented the thin film technologies used in the transistors and comparative study with the traditional one along with the quality, features functionalities and glimpses of the future display technology up to certain extend which suggest that there is scope for further study and R&D to explore this particular area which is highly demanded in the industry.

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