TOSHIBA

LCD Television Technology

Purpose

LCD's rise to prominence in the world of flat panel display technology has ushered in a need for those who use and service LCD based products to understand the panel technology. In order to perform this task, we will discuss the theory of the technology as it is currently being used.

Physical Makeup

LCD panels consist of several layers of materials designed to pass or block light at a specific moment in time (measured in micro-seconds), resulting in the reproduction of a video signal, much like the CRT did in direct view televisions. To help us understand the construction of a panel, we will refer to Figures 1 and 2.

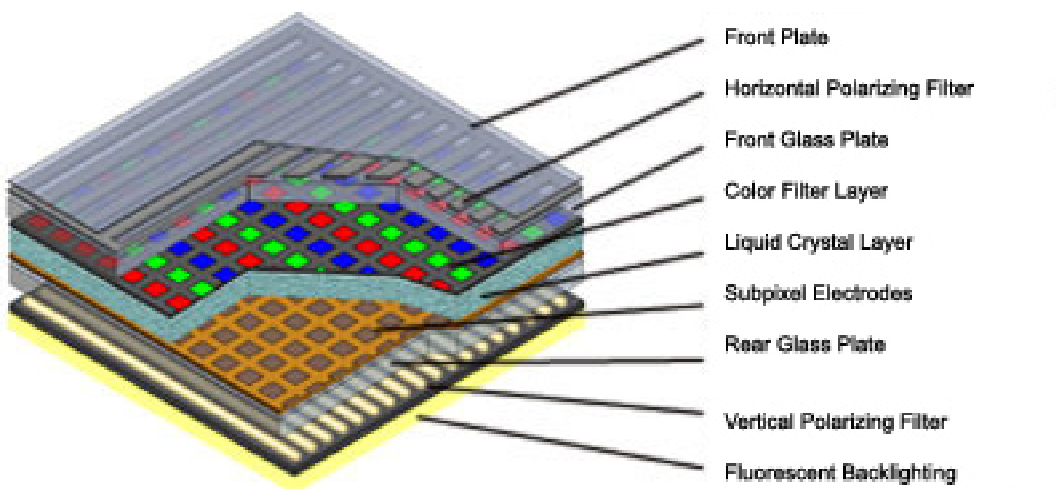

Figure 1

Figure 1 illustrates the various layers of materials along with a light source. Beginning at the bottom of our illustration, we have what is referred to as "backlighting".

- The backlight assembly is an array of cold cathode fluorescent lamps (CCFL), strategically placed for even light distribution. To further ensure even light distribution, a translucent sheet of diffusion material makes up the final layer of the "Backlight Assembly".
- Next, we have a sheet of polarized material (in this case, vertically polarized). This will allow only the vertically polarized portion of light created by the diffuser to pass through.
- The next layer of material is a glass plate containing Subpixel Electrodes (in this case, tiny switching transistors and electrodes etched in silicon), On top of the glass plate is a layer of Liquid Crystal.
- On top of that is a sheet containing red, green, and blue translucent "elements" arranged in columns and rows. This is referred to as the "color filter". Each "element" is sometimes referred to as a subpixel. The reason for the name "subpixel" is it takes three of them to make up a pixel; one red, one green, and one blue. This layer is covered by a second glass plate.
- Finally, there is another polarized filter (this time, horizontally polarized). The final layer is called the "front plate".

Figure 2 illustrates a BASIC block diagram of what we saw in Figure 1. Understanding backlighting, diffusion, and polarization is relatively easy because it is not new to us. We are all familiar with lighting, diffusers, and polarized sunglasses.

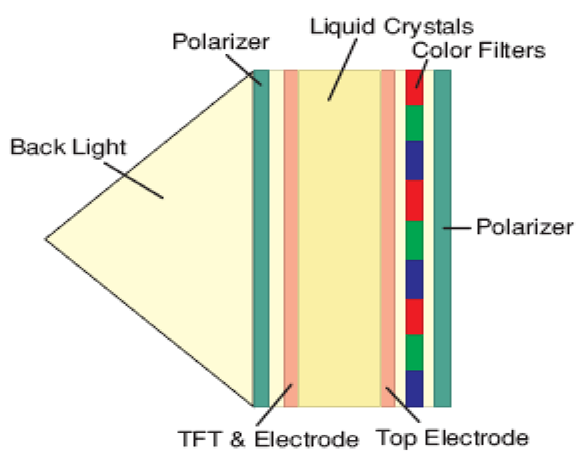

Figure 2

Liquid Crystal

Liquid Crystal and how it behaves is completely new to us and will require an in-depth look at the theory behind its use. There are several forms of Liquid Crystal; however, the form we are interested in is called "Twisted Nematic" because the rod-type molecules can be twisted (spiraled) when reacting to an applied voltage. The degree of twist determines the amount of light allowed to pass through. This action works in conjunction with the vertical and horizontal polarizers (to be discussed later).

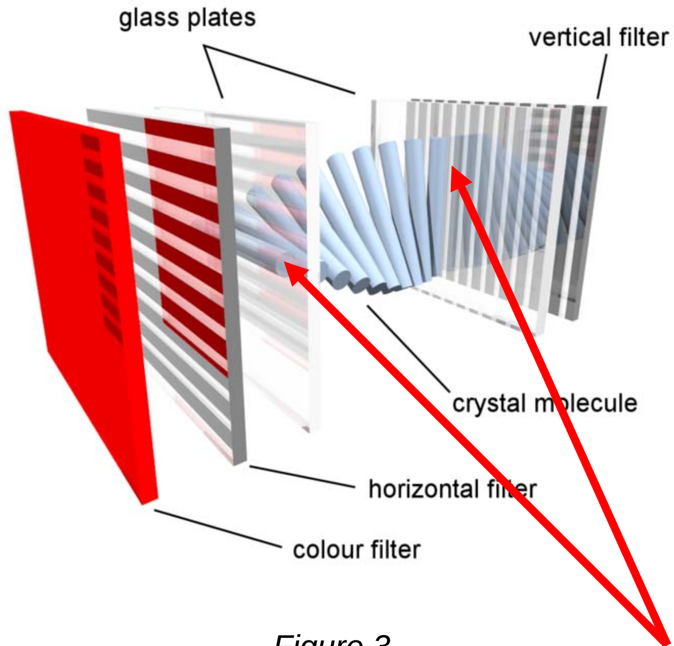

Figure 3

Figure 3 is a graphic showing the Liquid Crystal after having been twisted. If we look carefully, we can see that the end rods of the molecule have been twisted to align with the horizontal filter (on left) and the vertical filter (on right). This configuration will allow maximum light to pass through the filters to the selected elements in the color filter.

TFT, Elements, and Pixels

TFT is an acronym for "Thin Film Transistor". Every element of every pixel has its own TFT (switching transistor). The transistors are arranged in a matrix on a glass substrate and when selected (via digital address), will illuminate the selected element(s) (by twisting the Liquid Crystal). The level of illumination is determined by the level of applied voltage. Each TFT has a capacitor capable of maintaining that applied voltage until the next refresh cycle. Just as in CRT technology, the various combinations of red, green, and blue can produce a massive array of colors. Earlier in this article it was mentioned that each pixel contained 3 "elements" (sub-pixels). The level of light passing through each element will determine the color and intensity of that particular pixel.

Figure 4 is a graphic illustration of the liquid crystal molecules being twisted by varying degrees within one pixel.

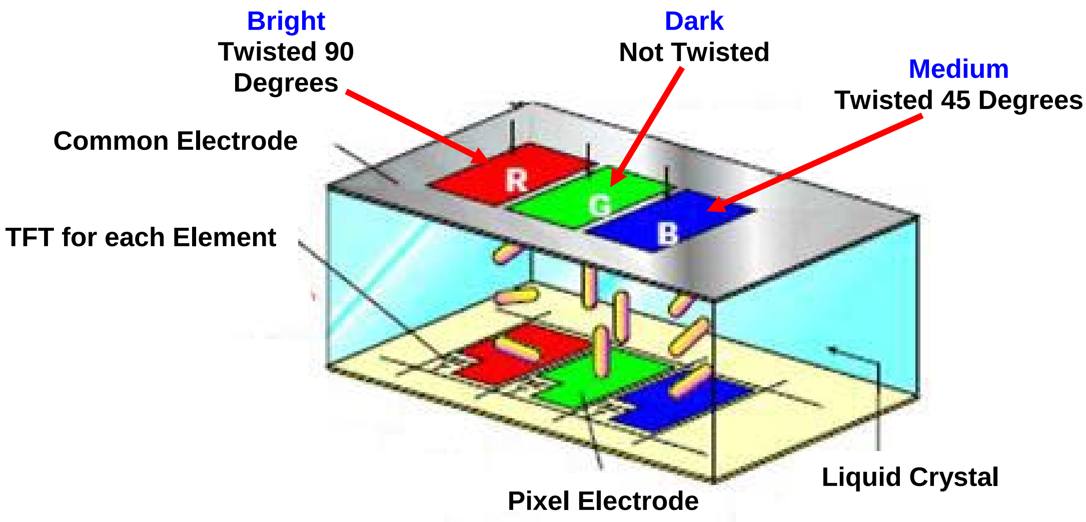

Figure 4

We can see each element has its own TFT. Careful examination reveals the different alignment of liquid crystals on each element. The combination of the three elements will produce a pixel reflecting that color, i.e., blue plus green plus red will give us a white pixel if all elements are twisted by 90 degrees. Figure 5 is a graphic showing a 3 pixel array with TFT's.

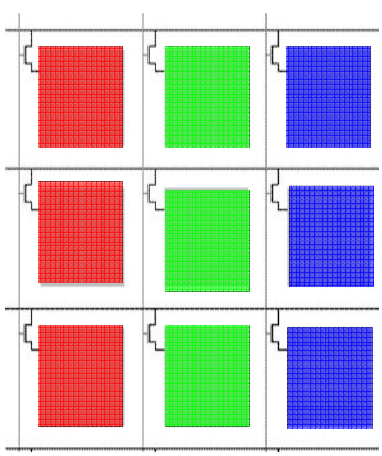

Figure 5

Each element of a pixel has it's own physical location. Addressing a particular element is based on its location in an X-Y axis. Figure 6 shows a section of pixels as they appear when sectioned out of the word "foot".

Figure 6

An LCD screen capable of producing a 1080p picture contains 2,073,600 individual pixels (1920 x 1080). That means 6,220,800 elements (and TFT's) are available to be addressed 60 or 120 times per second (depending on the refresh rate of the TV).

Driving the LCD Panel

Elements are arranged in columns and rows. In order to drive a particular location in a column and row, we must first have the ability to energize the particular TFT at that location. Figure 7 is a schematic representation of how one address can be selected from the matrix. You will notice, if a voltage is applied to X1 and Y2, the TFT at that location will turn on, charge the capacitor, and maintain a certain voltage level across the LC material until the next scan. The scan process is: A row is turned on, a signal is sent down selected columns, the TFT's at the intersections are turned on, and the capacitors are charged energizing the LC materials at the chosen locations. The next row will now be scanned, and so on until the bottom of the panel is scanned at which time the process will begin at the top again. As previously mentioned, this process occurs at the refresh rate of the TV.

Active Matrix

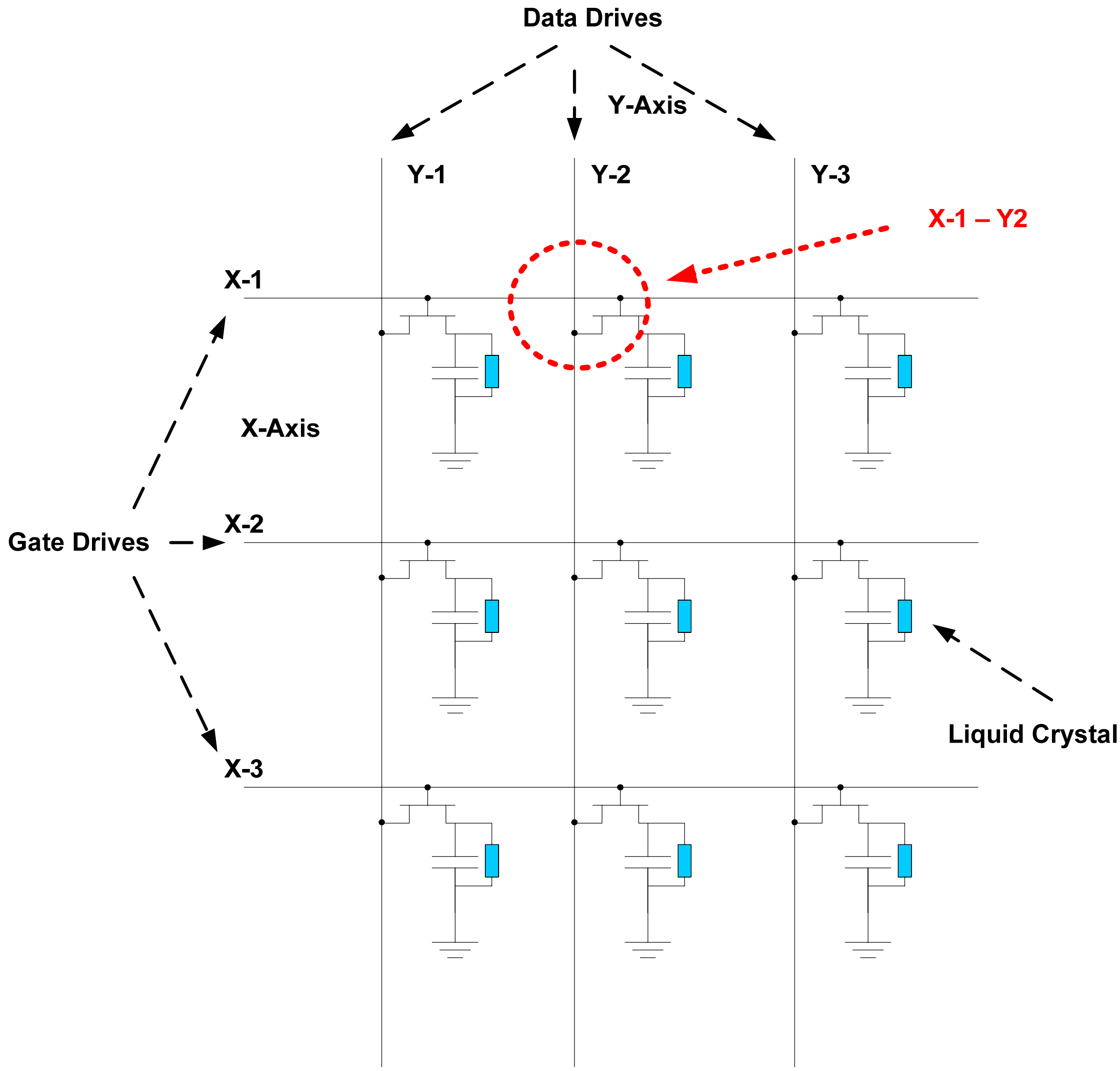

Figure 7

Because each element is switched by a separate transistor, the entire matrix is considered to be an **Active Matrix**. This method provides a fast response time with minimal pixel crosstalk.

Putting it all Together

Figure 8 will help correlate the theory we have just discussed with a complete LCD panel.

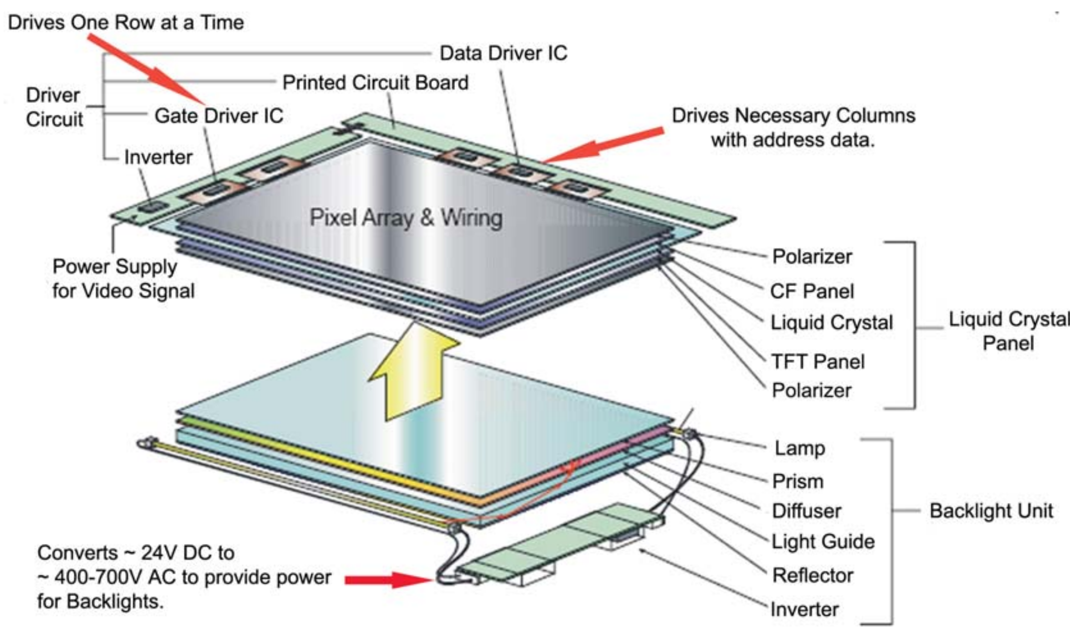

Figure 8

The LCD panel cannot work without signal reception and processing circuitry. When the video signals are received and processed, they are sent to a printed circuit board called the "Control Panel". This panel processes the digital information and applies it to the LCD panel. The information is then applied to the rows and columns in the form of X and Y axis locations via the driver IC's.

Resources

Wikipedia.com
Behardware.com
LG Electronics
Howstuffworks.com
Google.com
Chooseyourtv.com