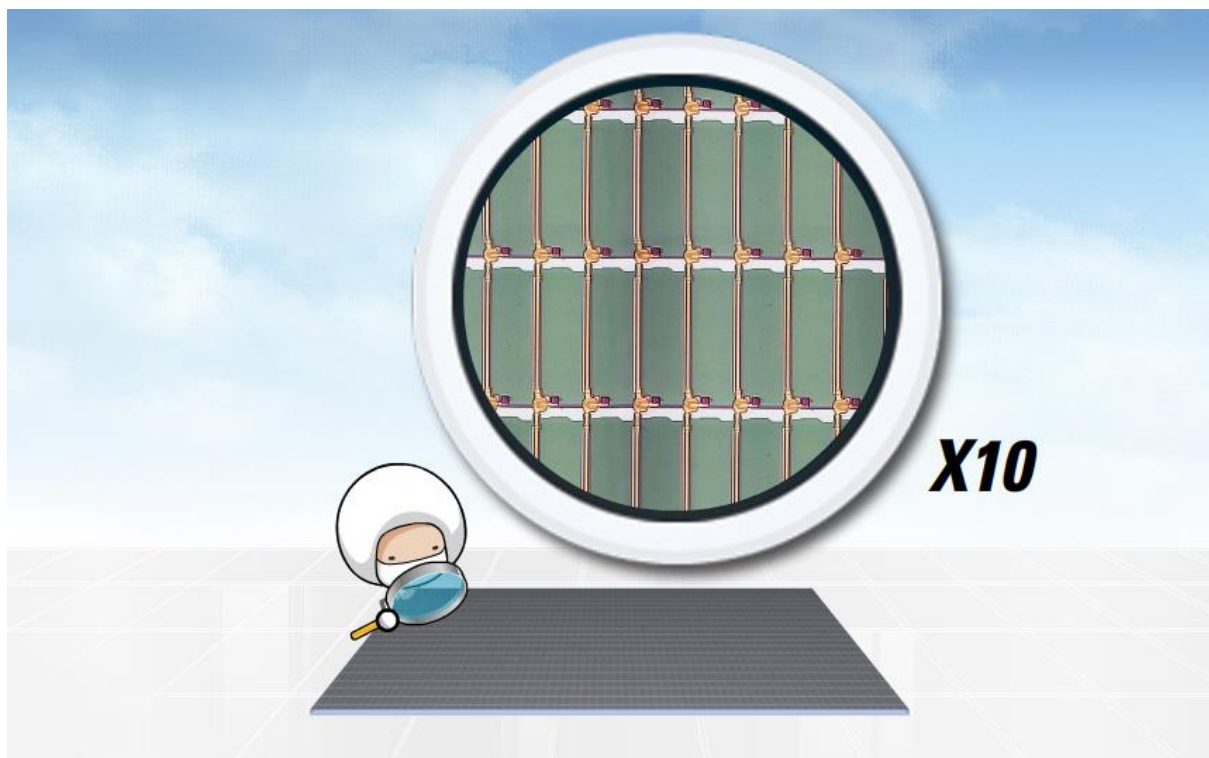


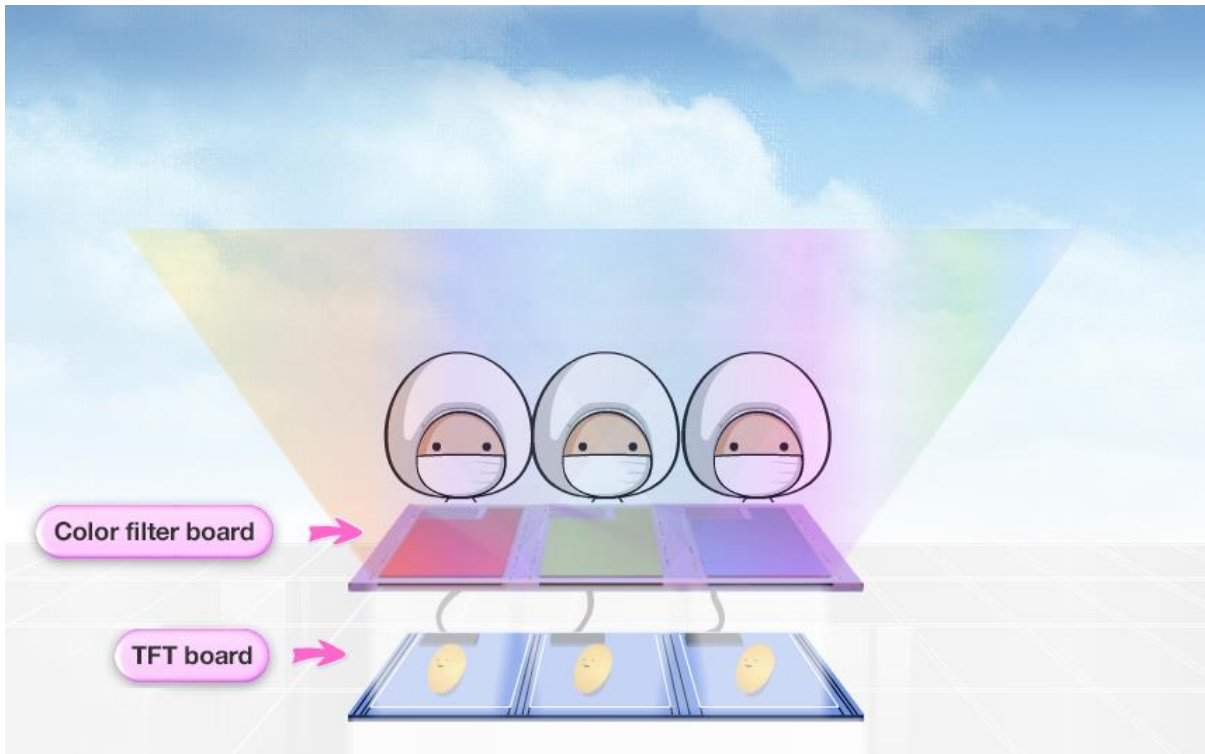
TFT-LCD Production Process Explained

Ever wondered how the TV and monitor displays you use every day work? The TFT-LCD manufacturing process consists of a set of processes for producing TFT, color filtering, cell, module and others. LG Display Newsroom gives a detailed, but easy to follow explanation of the entire steps below.

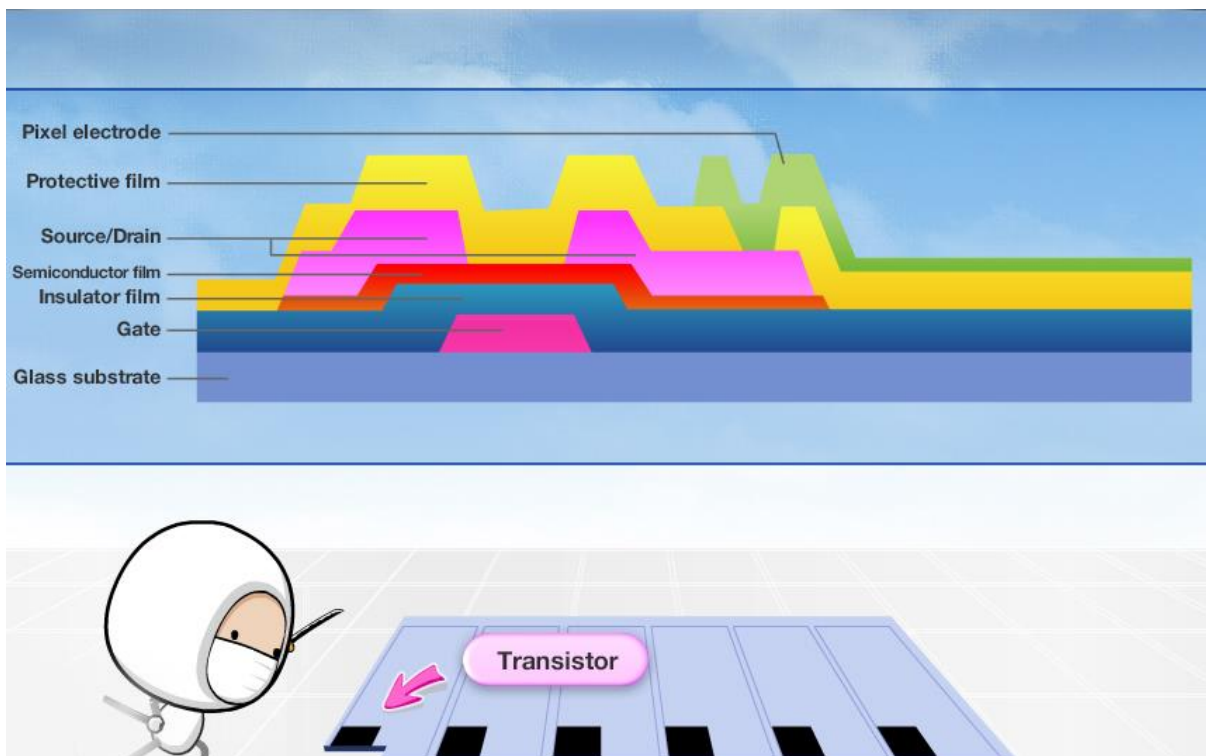
Close Look at the Thin Film Transistor (TFT) Process



Let's take a closer look at the production process for a TFT board, the bottom-most layer of an LCD panel. The image above depicts a TFT board, which consists of rows of small rectangular sections that together resembles a chessboard. Each rectangular section is a pixel, and each pixel contains a transistor that controls its function. The TFT process is the process that builds these transistors on top of a glass substrate.

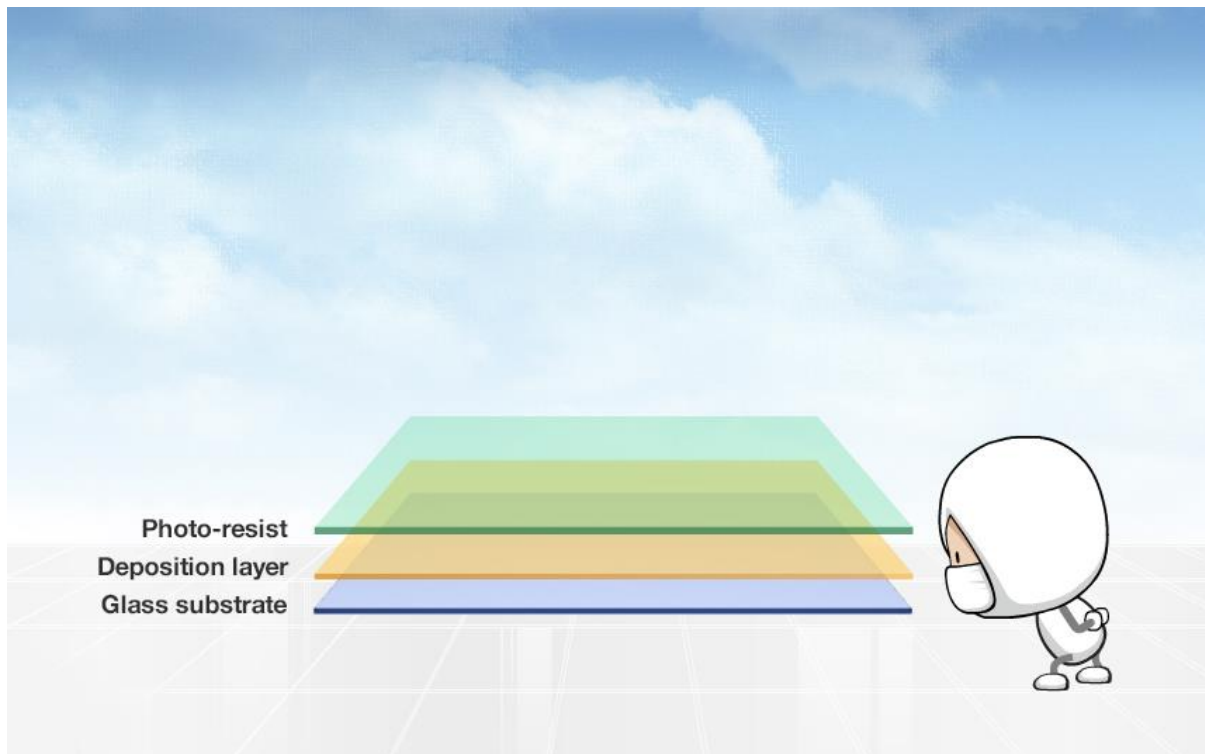


So, what exactly is a transistor? Simply described, a transistor is a microscopic switch that controls the flow of electricity in the direction of liquid crystal and regulates the movement of the liquid crystal.

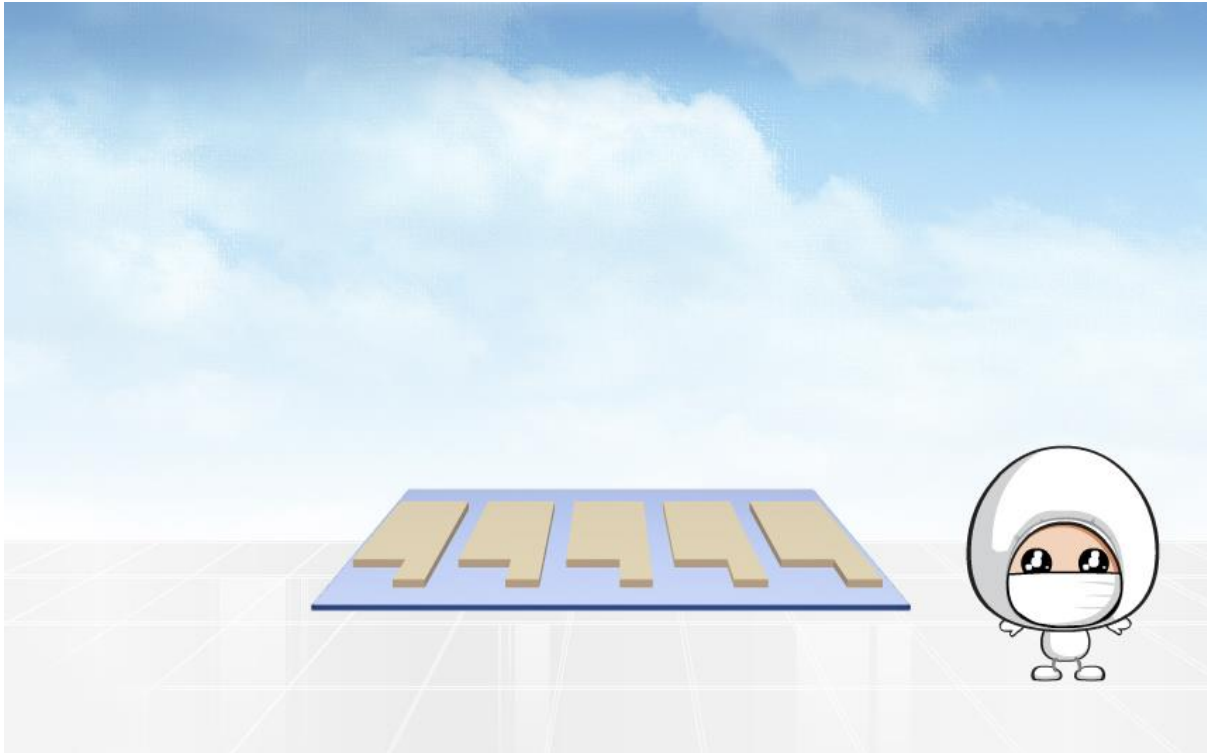


On top of a TFT board are millions of tiny transistors that are invisible to the naked eye, each of which are one hundredth of the thickness of a single strand of hair. If you examine the

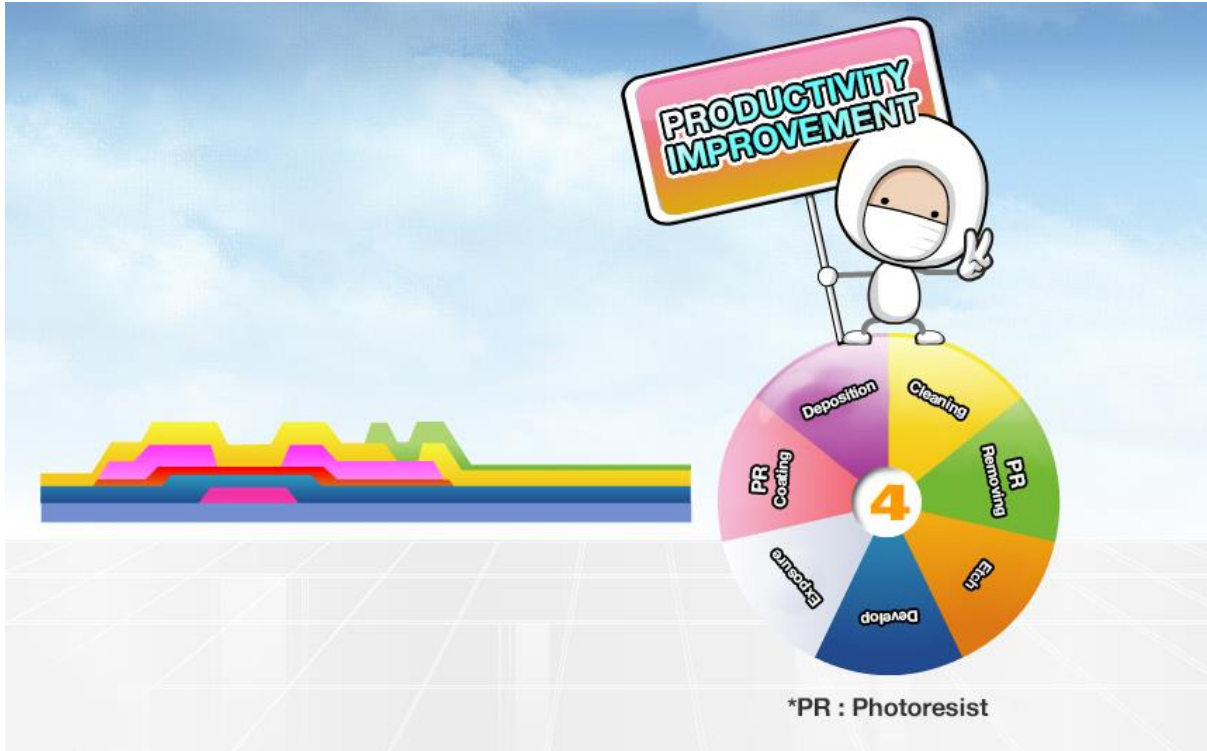
transistor up close, you would notice that it consists of several layers. Now, let's see how each layer is produced, starting with the first layer.



After cleaning the glass substrate (Cleaning), it is coated with a layer of film, which is essential in creating the appropriate shape (Deposition). Then, a layer of light-sensitive material is spread out on top of this film (Photo-resist coating). Through these steps, we can create two layers, on which we can build parts of a transistor of various shapes and sizes as you can see in the picture above.



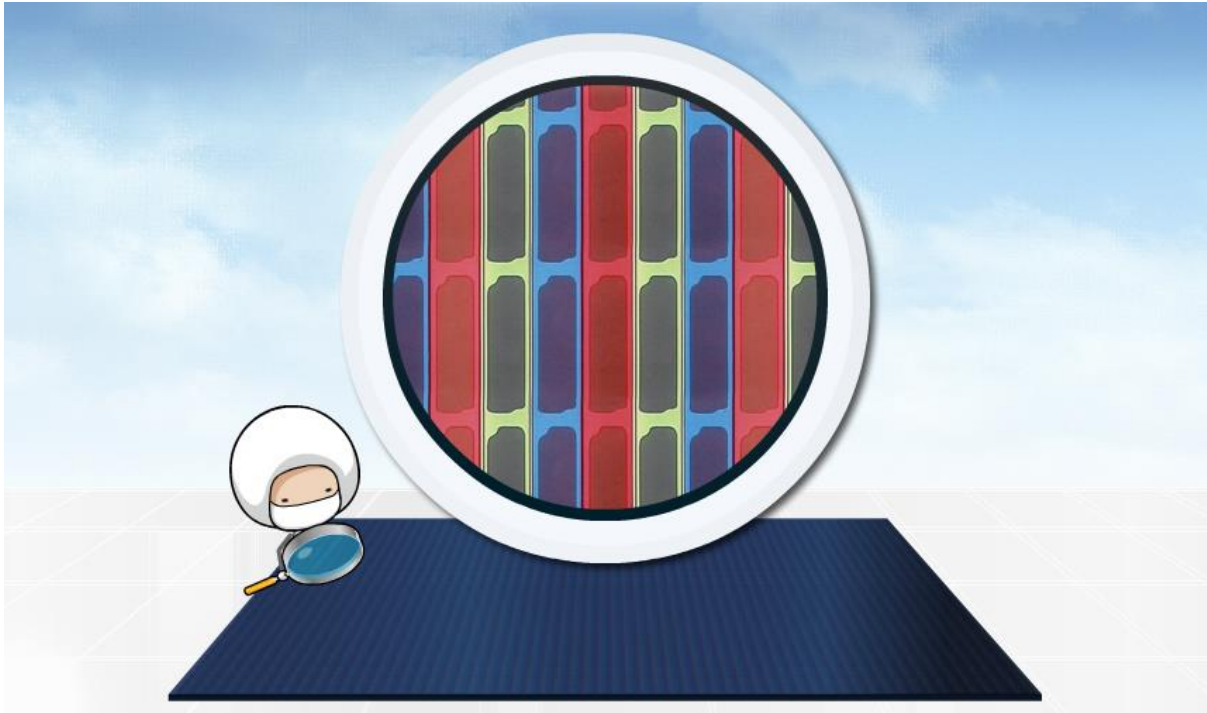
In order to do this, we place light masks of desired patterns on top of the glass substrate and shine light over them. (Exposure). This allows us to remove the parts of the top layer exposed to the light and transfer the pattern on the light mask onto the glass substrate. The same procedure is repeated to remove the second layer and the photo-resist that lies below it (Etching). Once the surrounding parts of the light masks are removed, we are left with a part that, together with other parts that can be made using the same procedure, makes up the transistor (Photo-resist).



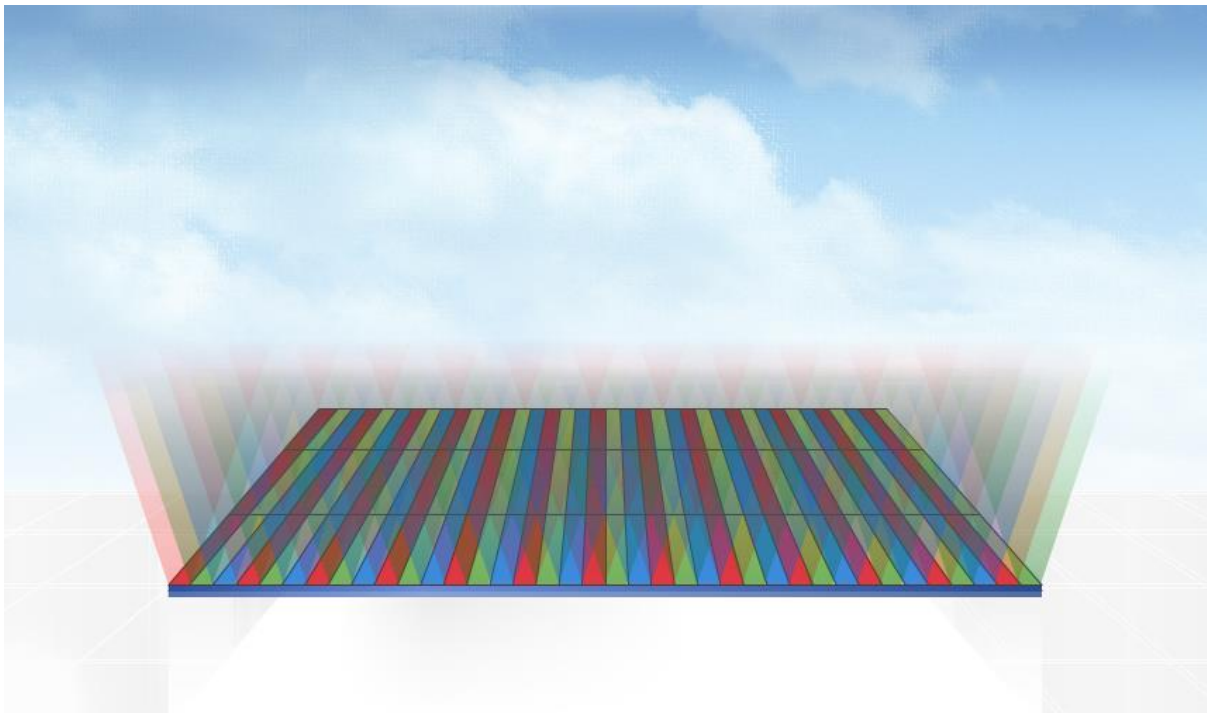
In the past, the entire sequence had to be repeated eight times. However, technology has developed such that we can make 2 to 3 layers at once, allowing us to build a transistor by repeating the sequence only 4 times.

Close Look at the Color Filter (CF) Process

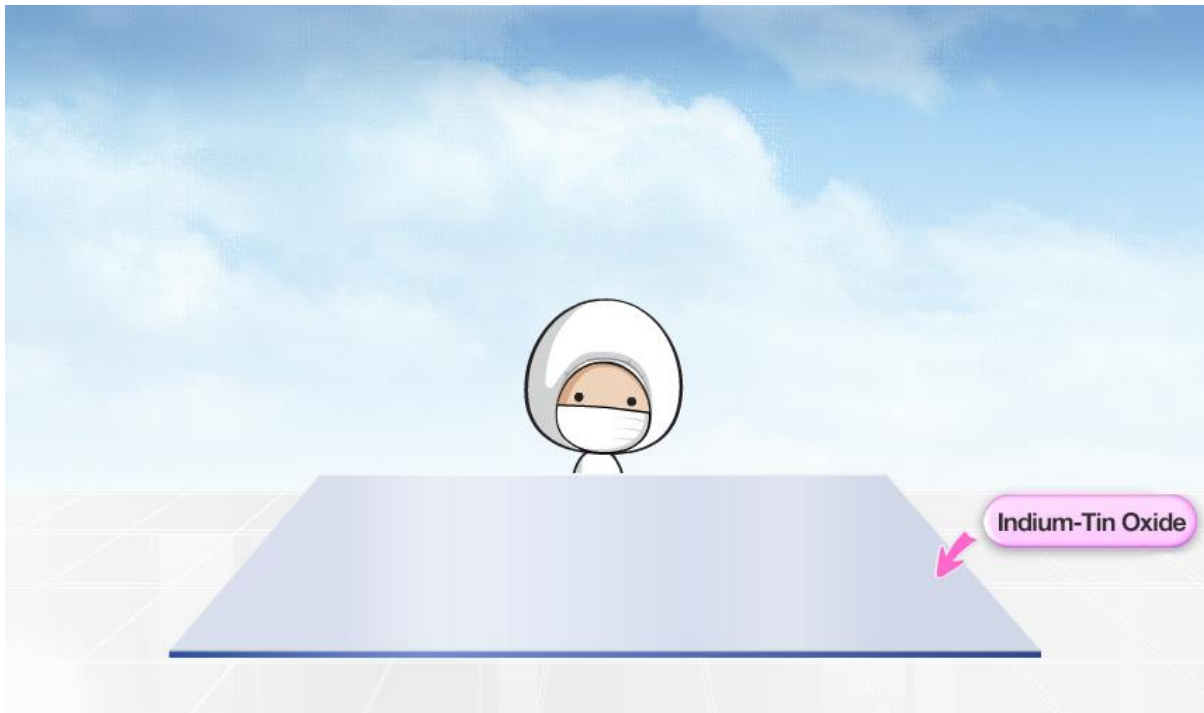
The next step to producing an LCD panel is the color filter process.



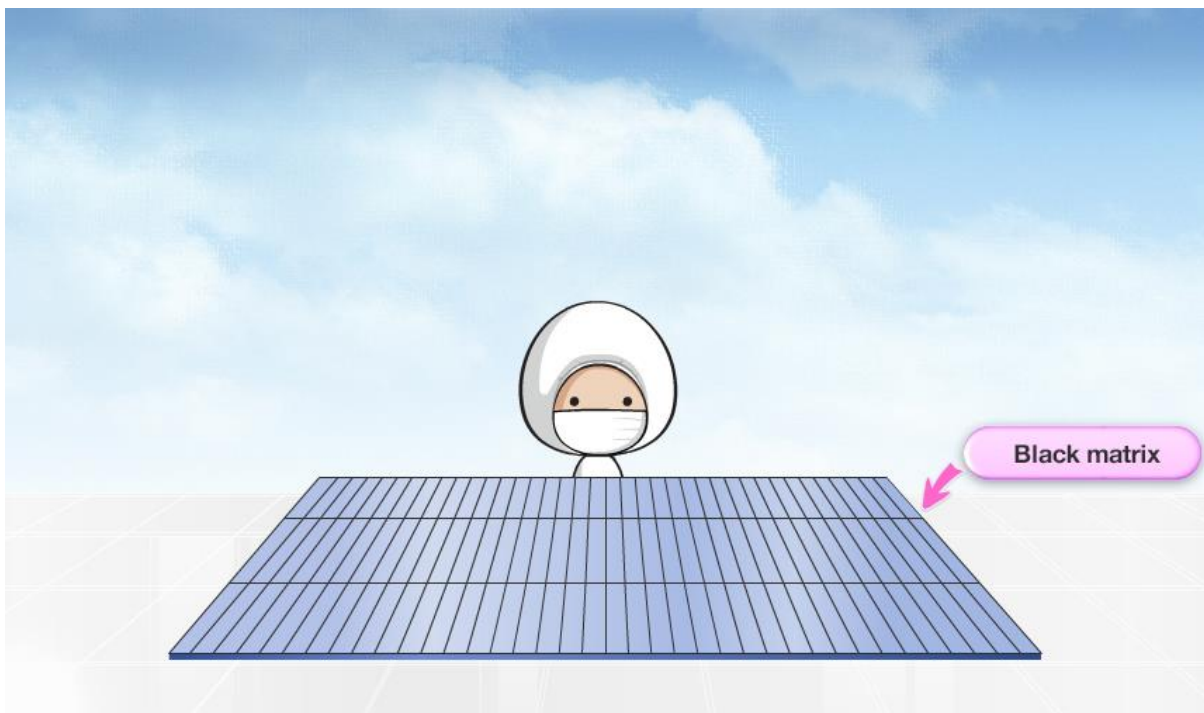
The picture above depicts a color filter. A close up of the color filter reveals that it consists of several groups of red, green, and blue pixels.



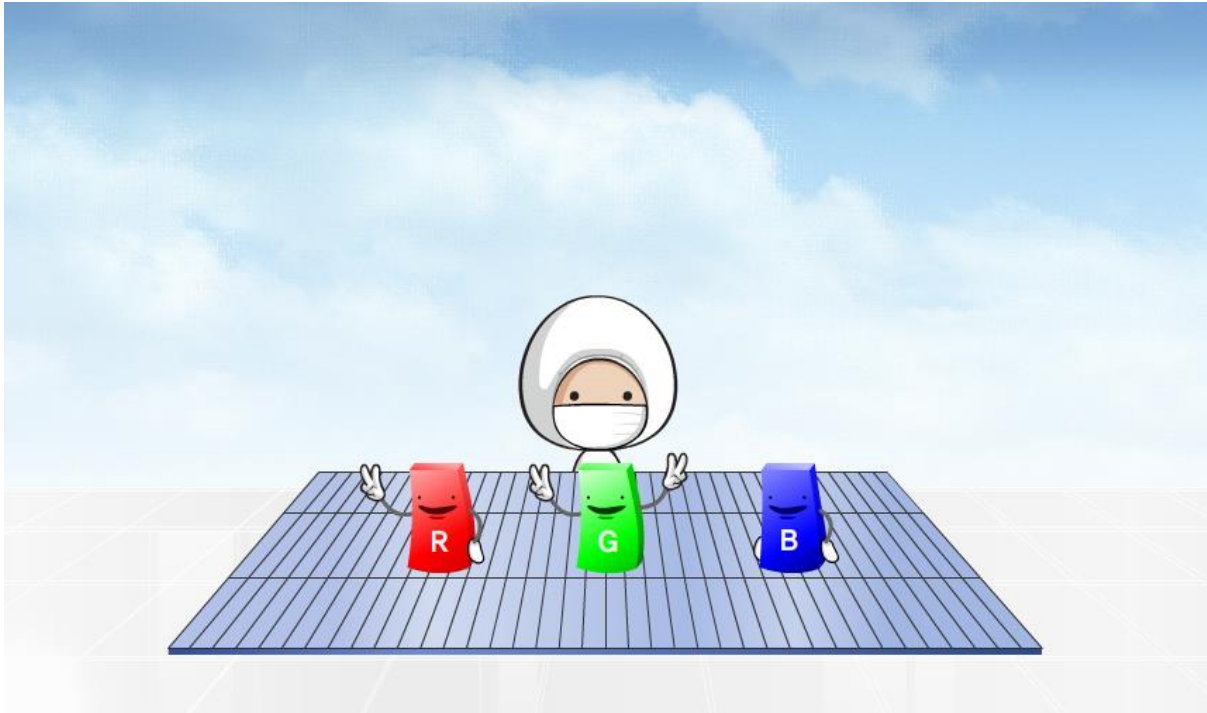
The color filter process build these color pixels on the thin glass substrate. Originally, the TFT-LCD's backlight produces white light, but as it goes through the color pixels, it gives rise to a various combinations of red, blue and green lights, giving rise to colorful images we see on the screen.



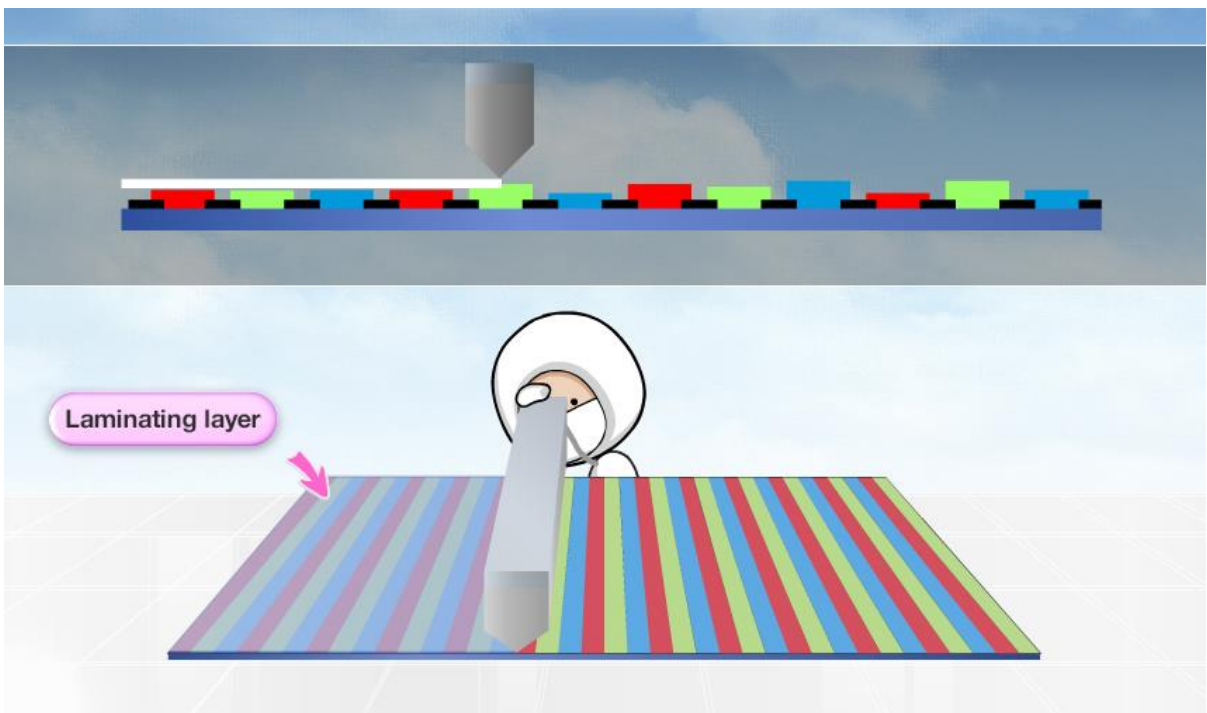
How the color filter board is built is as follows. First, the glass substrate needs to be cleaned up, and then it is coated with a transparent layer known as the Indium-Tin Oxide Film (ITO) for electrostatic screening.



Next, a black chessboard-like shield known as the Black Matrix is built on the other side of the glass substrate to prevent the distinct color of each pixel from mixing with one another.



The next step is to create red, green, and blue pixels. First, a light-sensitive red material (Red Photo-Resist) is spread out onto the glass substrate. Next, after shooting light onto the mold (Mask), we must remove the exposed area in order to create our desired shape. Lastly, we harden the red material by heating it in an oven. Through repeating this process, we are able to create green and blue pixels.



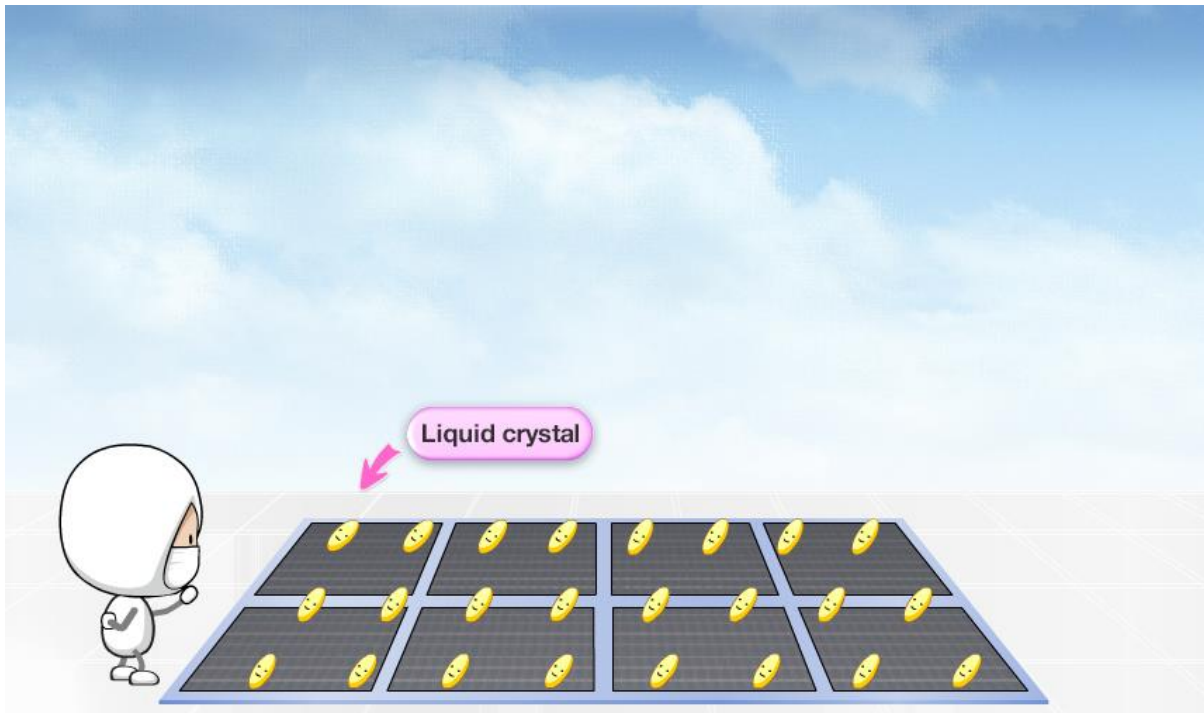
The result of this process, however, is pixels of different heights. Another laminating layer needs to be applied in order to even out the surface of the pixels. We then attach a small supporting column. Finally, when we attach the TFT board in the next process, the use of

small supporting columns helps maintain a uniform distance between the color filter and the TFT board.

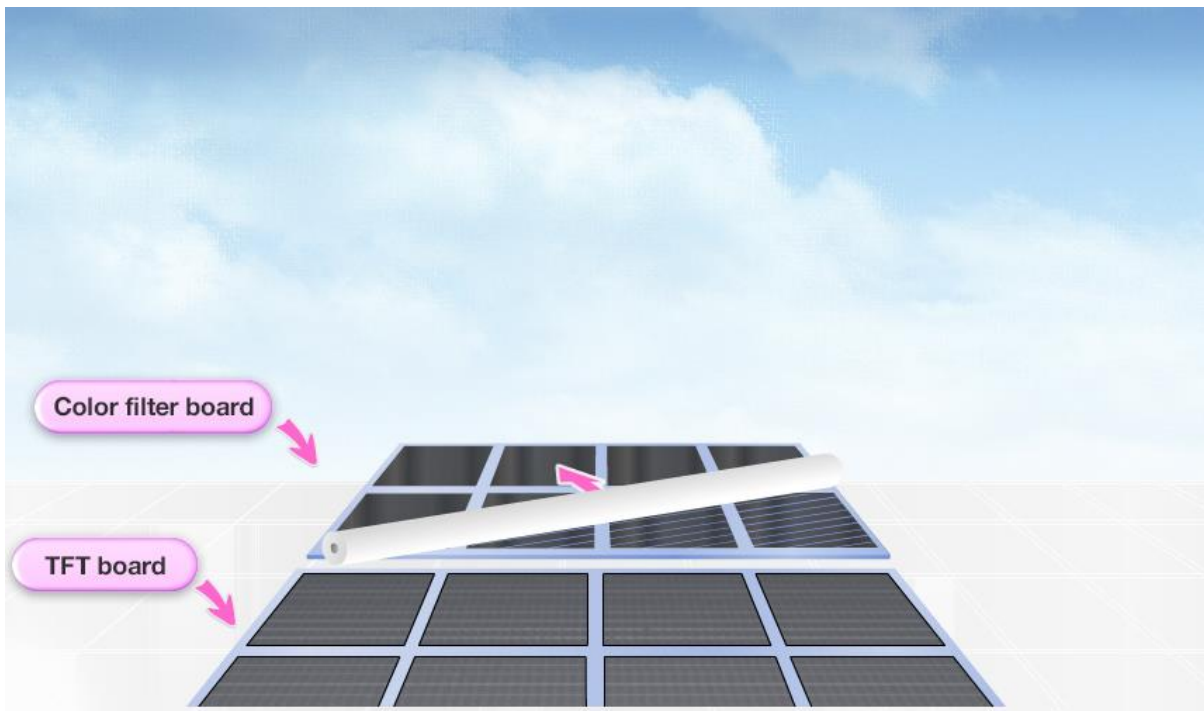
Closer Look at the Cell Process



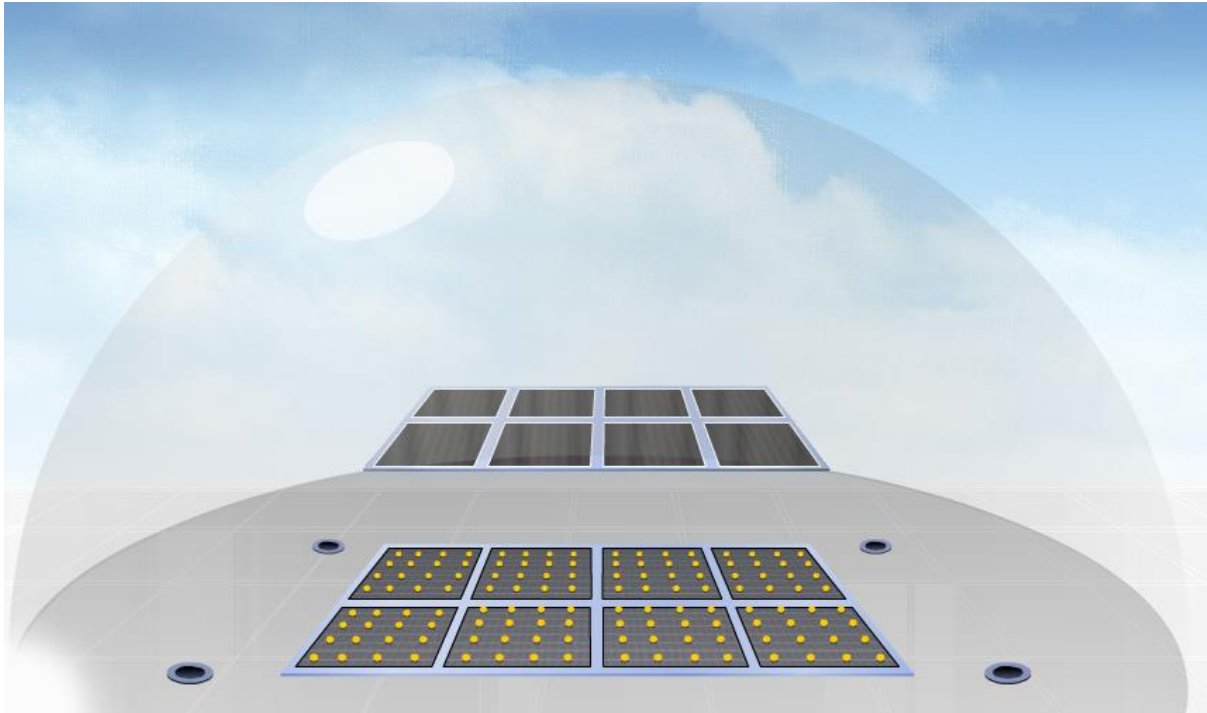
The following step is the cell process, the step in which the TFT board is combined with the color filter and is cut into appropriate sizes. There are three steps to the cell process.



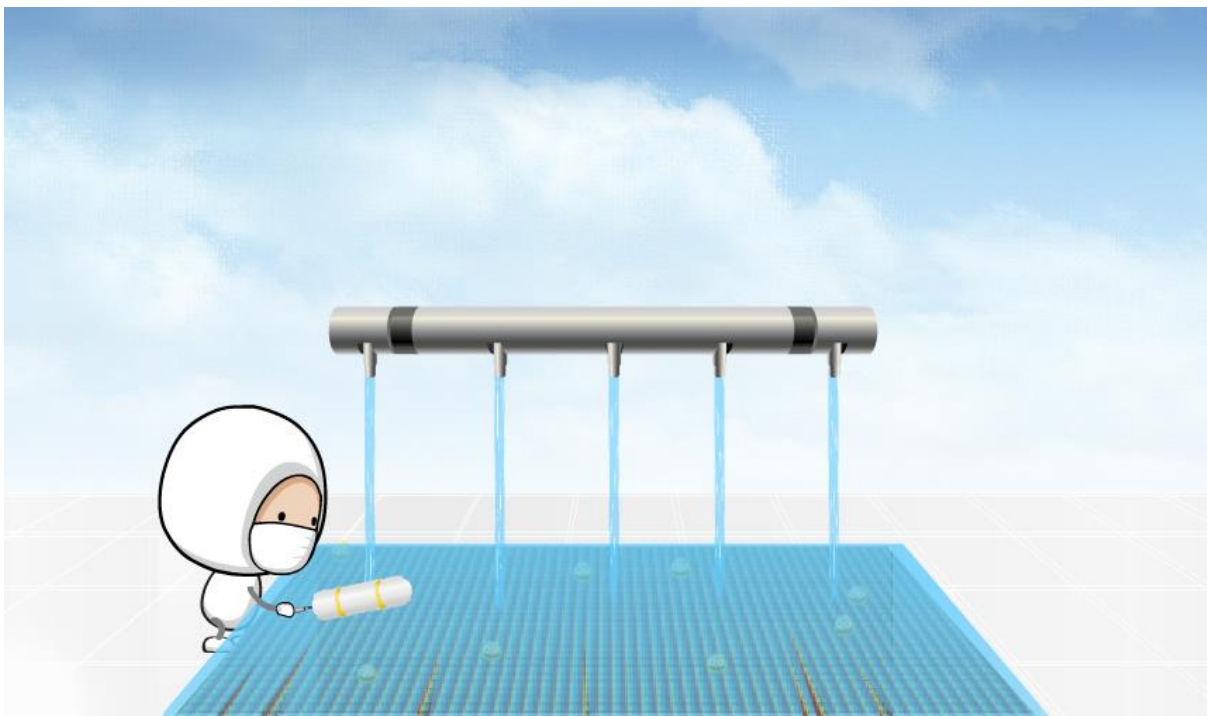
The first step is known as the alignment process, which aims to align the liquid crystal in a uniform direction. How this can be achieved is easier than it sounds.



After thorough cleaning of the TFT board and the color filter, polyimide layer is printed onto the TFT substrate and is hardened in the oven. Next, using a revolving roller intertwined with a soft cloth, we create a series of shallow grooves that allows the liquid crystals to orient in a uniform direction.

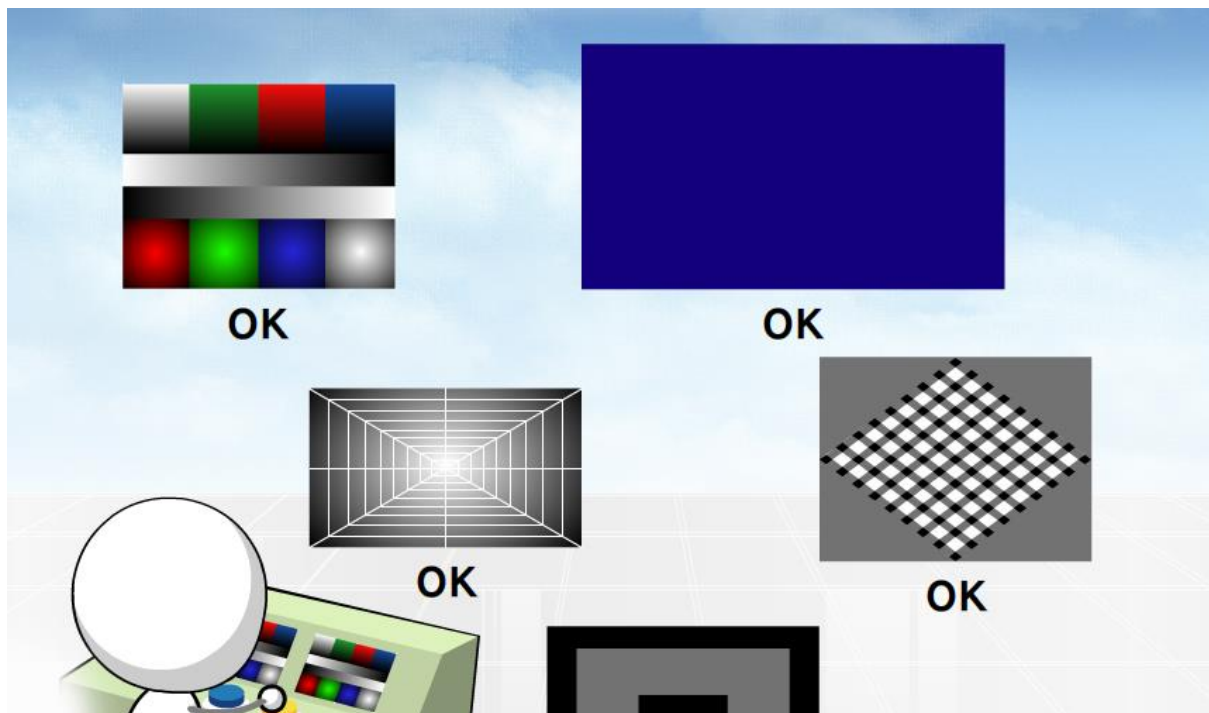


The next step is the combination process in which the TFT board and the color filter are sealed together in a vacuum. First, a specific amount of liquid crystals are dispensed on top of TFT board and an adhesive is applied to the color filter so it attaches to the TFT board. Next, the glass substrates are sealed in a vacuum. During this phase, the liquid crystals spread evenly between the two glass substrates.



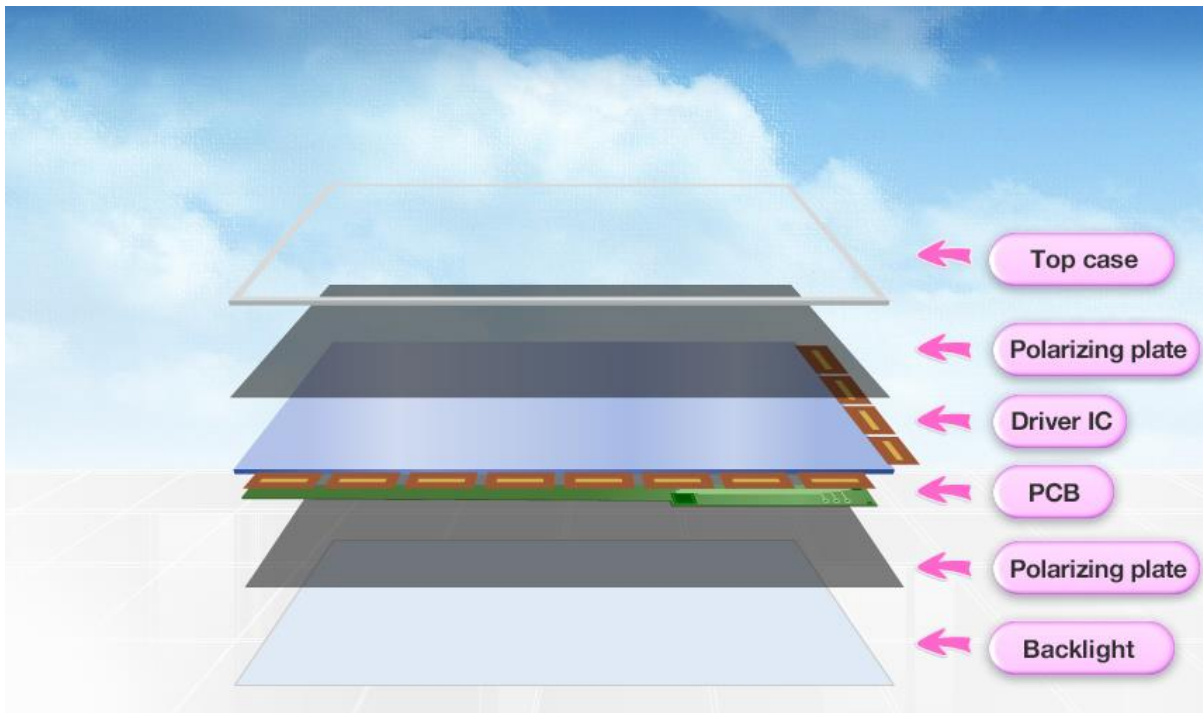
The third step involves making a panel by cutting the glass substrates in to the desired

dimension. First, both sides of the glass substrates need to be cut simultaneously into their appropriate sizes. Then, a grinder is used to smooth the edges. The panel is then cleaned to remove any leftover dusts or debris.

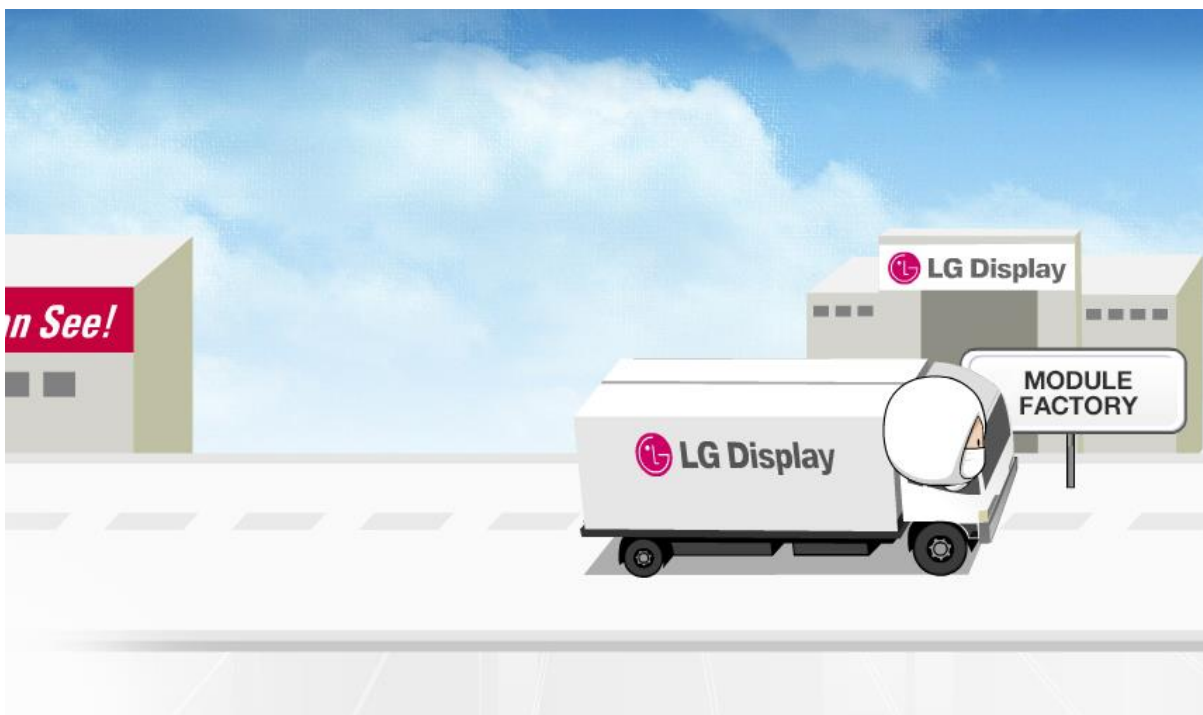


Finally, an electrical signal is given to the finished panel to verify that all colors and shapes are accurately displayed on the screen.

Closer Look at the Module Process



The Module Process takes place after the TFT color filter and cell process. It involves assembling components such as a polarizing plate, a driver IC(Integrated Circuit), PCB(Printed Circuit Board), a backlight and top case.

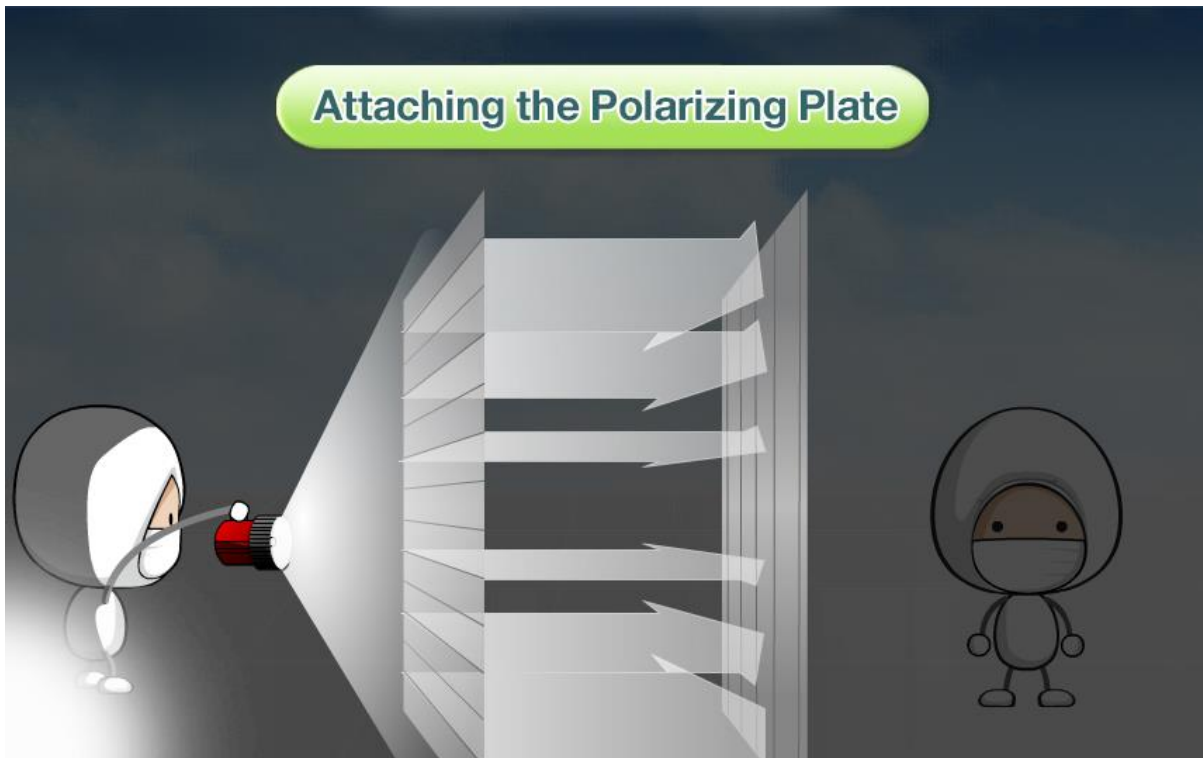


The panels completed in the cell process are packed and sent to the module processing area.



The panels entering the module process are first cleaned with clean water and paper made of organic materials to wash off debris produced during the cell process. The surfaces of the panels are then wiped with a soft brush and air-dried for the next process.

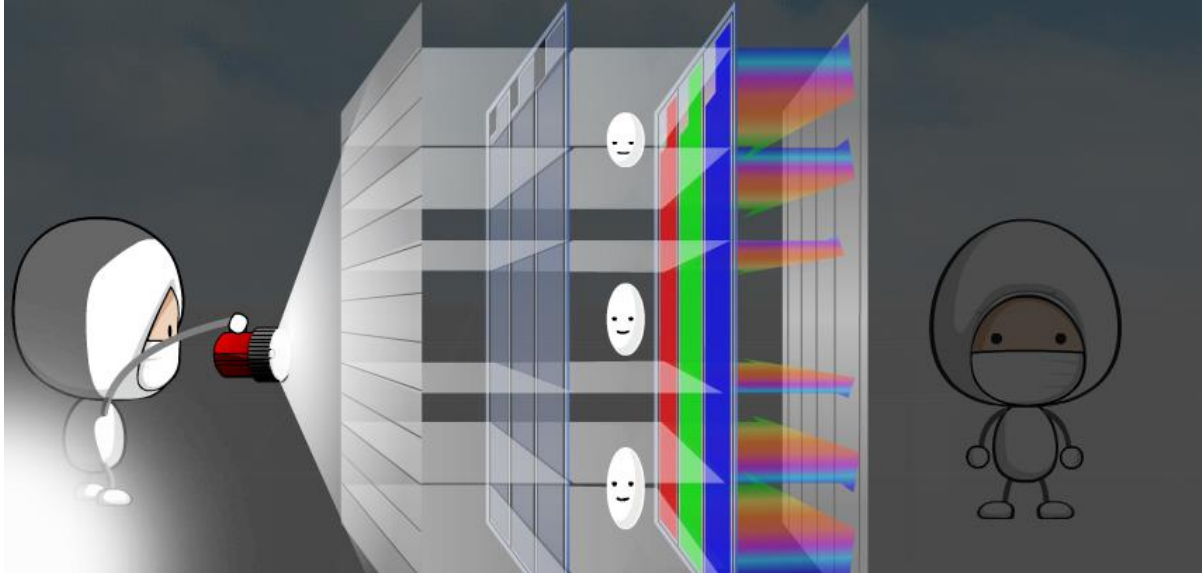
Attaching the Polarizing Plate



This process involves attaching polarizing plates to both sides of the panels cleaned in the previous step. A polarizing plate is a thin layer that allows the light through-either a horizontal or vertical plane. Removal of the protective film on the polarizing plate exposes an adhesive part that can be attached to one side of the panel using a roller.

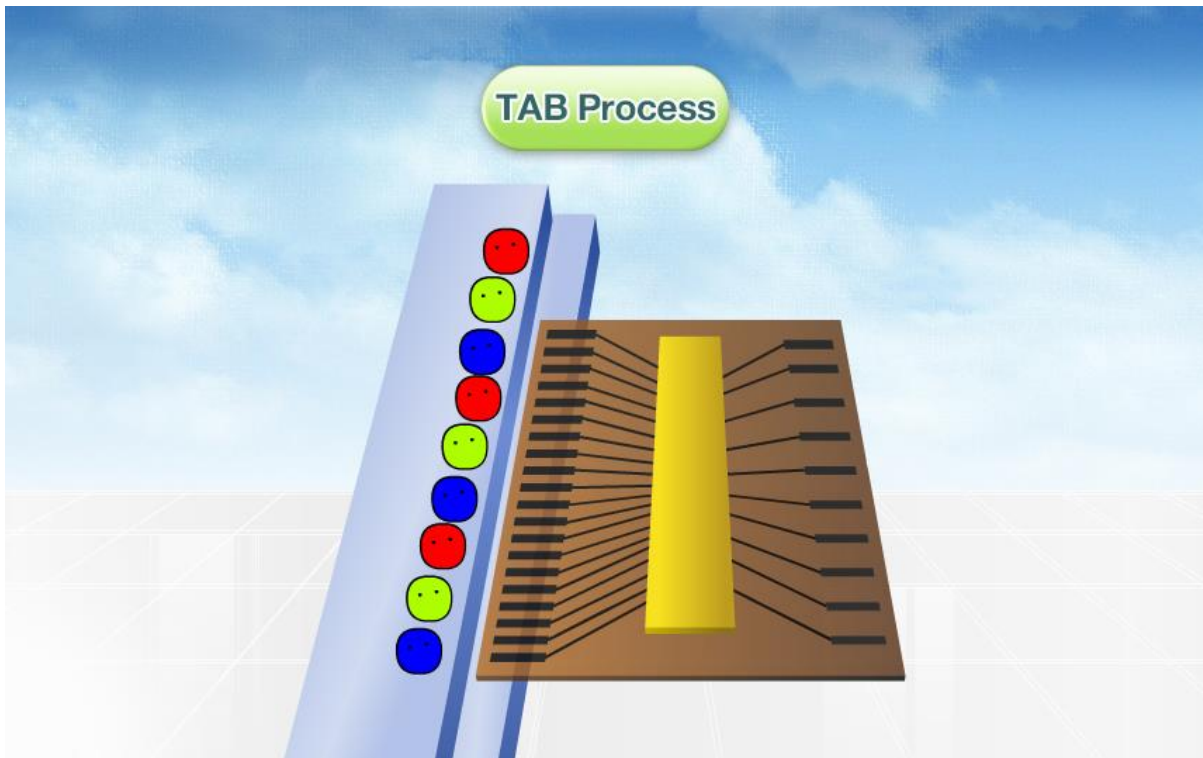
One plate attached to one side of the panel is horizontally oriented while the plate attached to the other side is vertically oriented, so that the light shined on one side cannot pass through the plate on the other side. Then a question arises: if the light cannot pass through the panel, how are the images on the screen produced? To maintain the perpendicular pattern of the polarized plate's other side, the reflected light is made unable to pass through to the opposite side. The light cannot pass through, so how are we able to see videos through the panel?

Attaching the Polarizing Plate

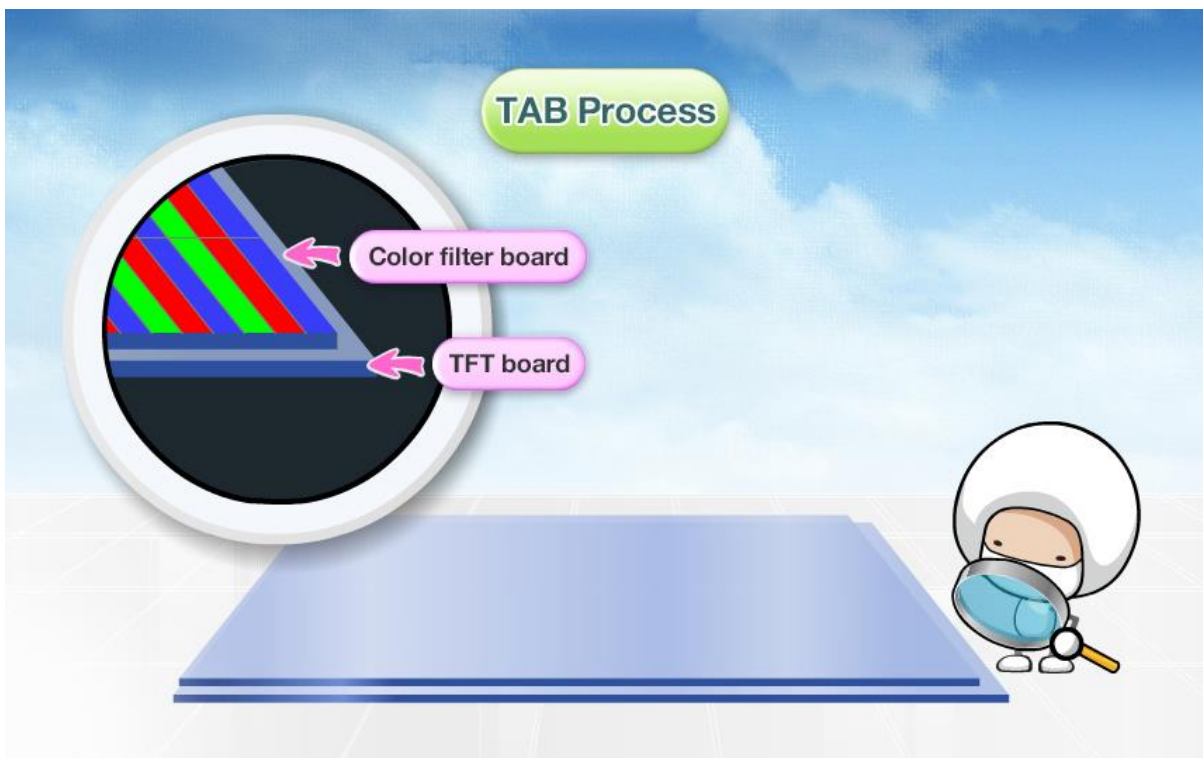


The liquid crystals in the TFT board play an essential role. First, the light from the backlight passes through the polarizing plate and reaches the TFT board. The direction of the light is changed here according to the alignment of the liquid crystals that orient themselves in reaction to the strength of the electrical signals they receive. The colorful images we see on TVs and monitors are created when the light passes through the red, green and blue pixels and the other layer of the polarized plate in various directions.

Tape Automatic Bonding Process

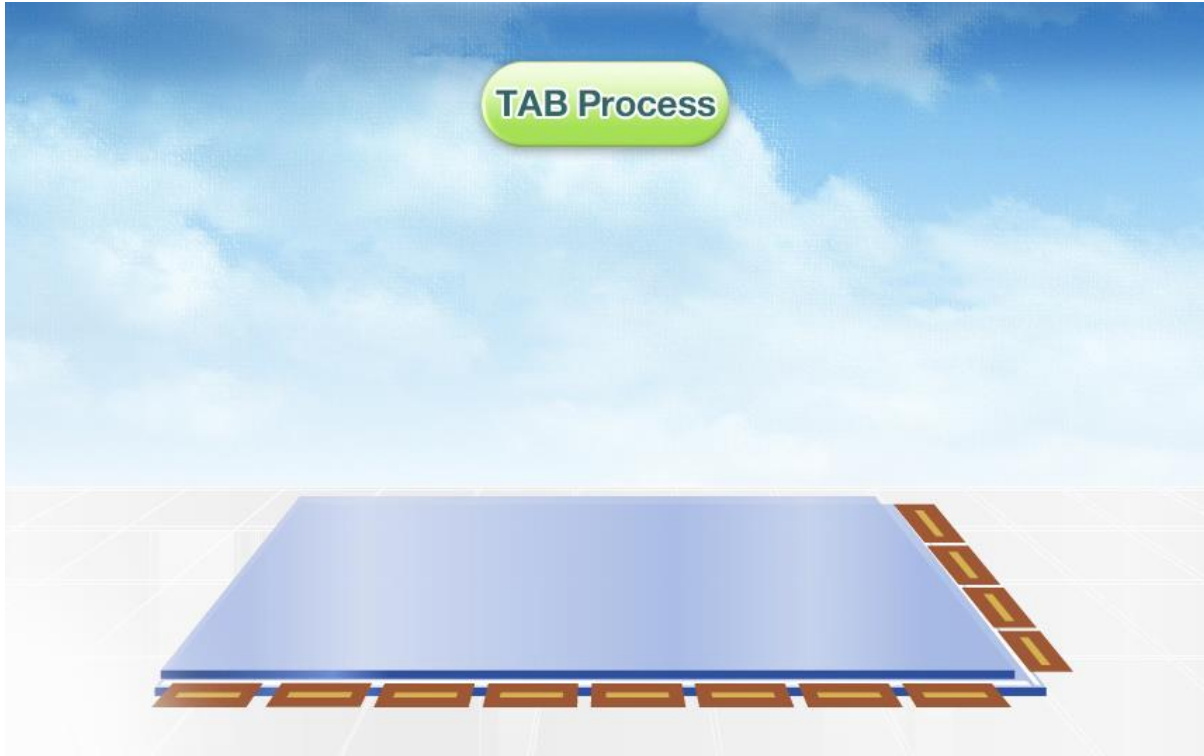


The tape automatic bonding process involves attaching a driving chip to the interior film. This film plays the role of a bridge for the delivery of electrical signals between panels. Let's now combine the film with the panels.



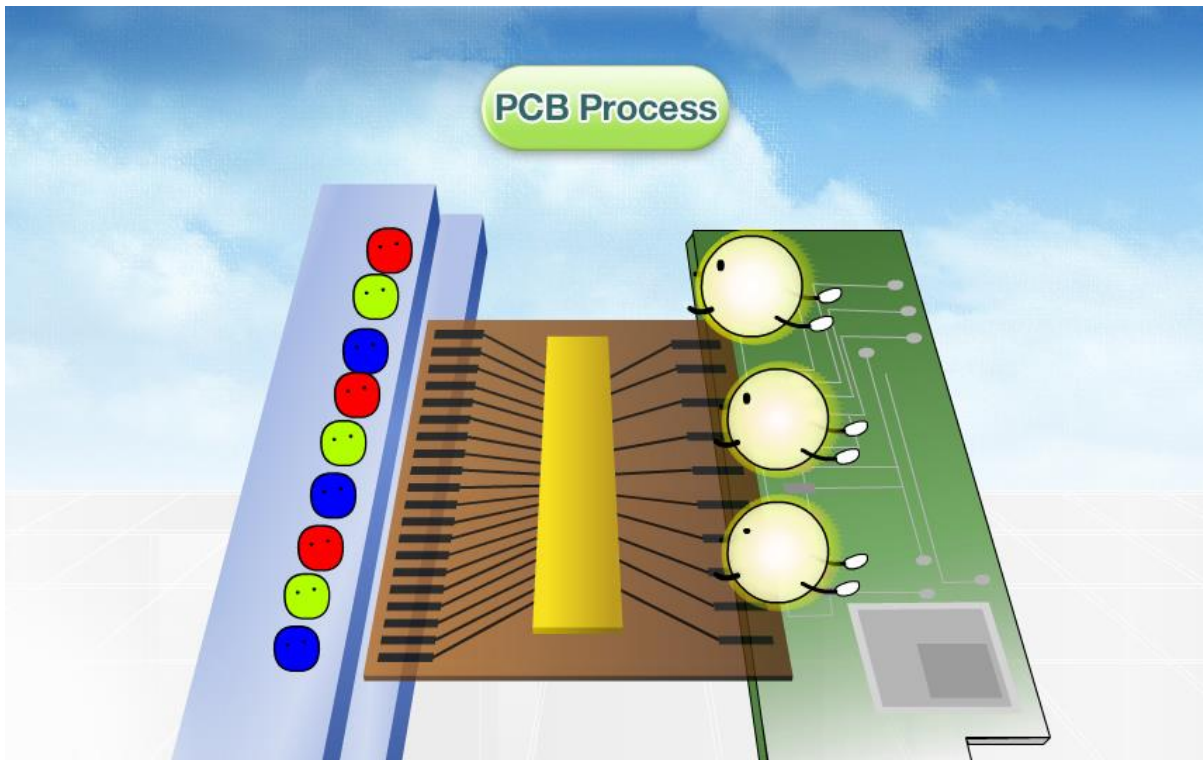
First, a camera is used to check the position on which the panel is placed. If we thoroughly

check the panels, we see that the TFT board is larger than the color filter. On the left over space around the edges of the TFT board, we apply an adhesive tape. Within the adhesive tape lies a conductor which allows electrical signals to run through the driving chip and the panel.

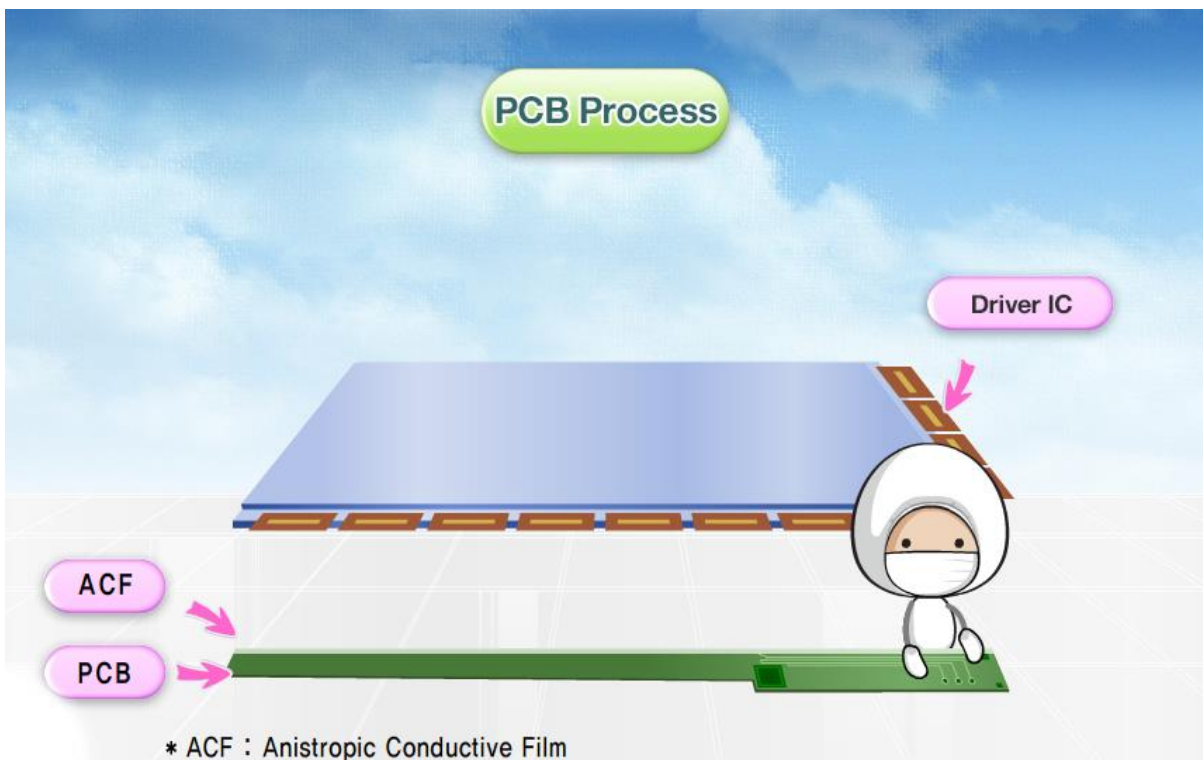


Like in the above projection, we cut out a long strand of film into a specific length and locate each piece when high temperature and pressure are applied; the panels are finally securely attached together.

Printed Circuit Board Process

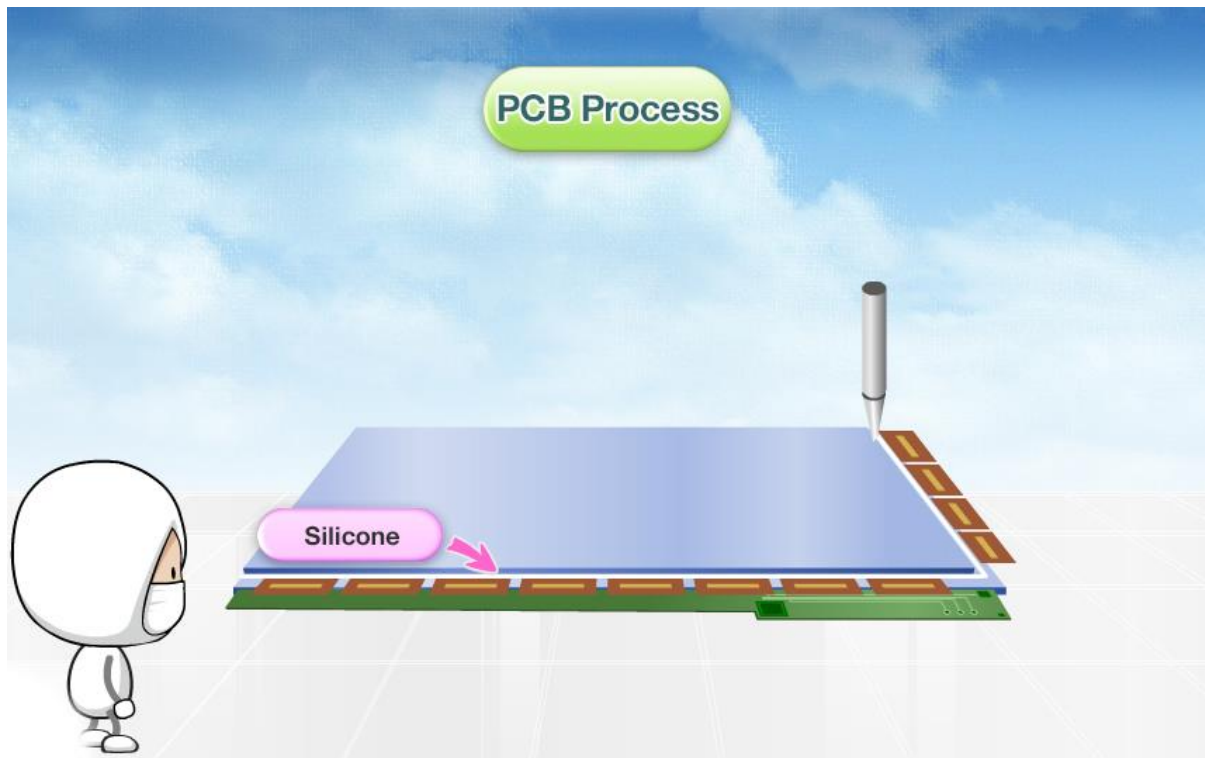


Now, let's see how the PCB (Printed Circuit Board) works. The PCB allows the driving chip to transfer external signals to the built-in film. The PCB plays the role of receiving external signals and transferring them to the driver chip inside the interior film.



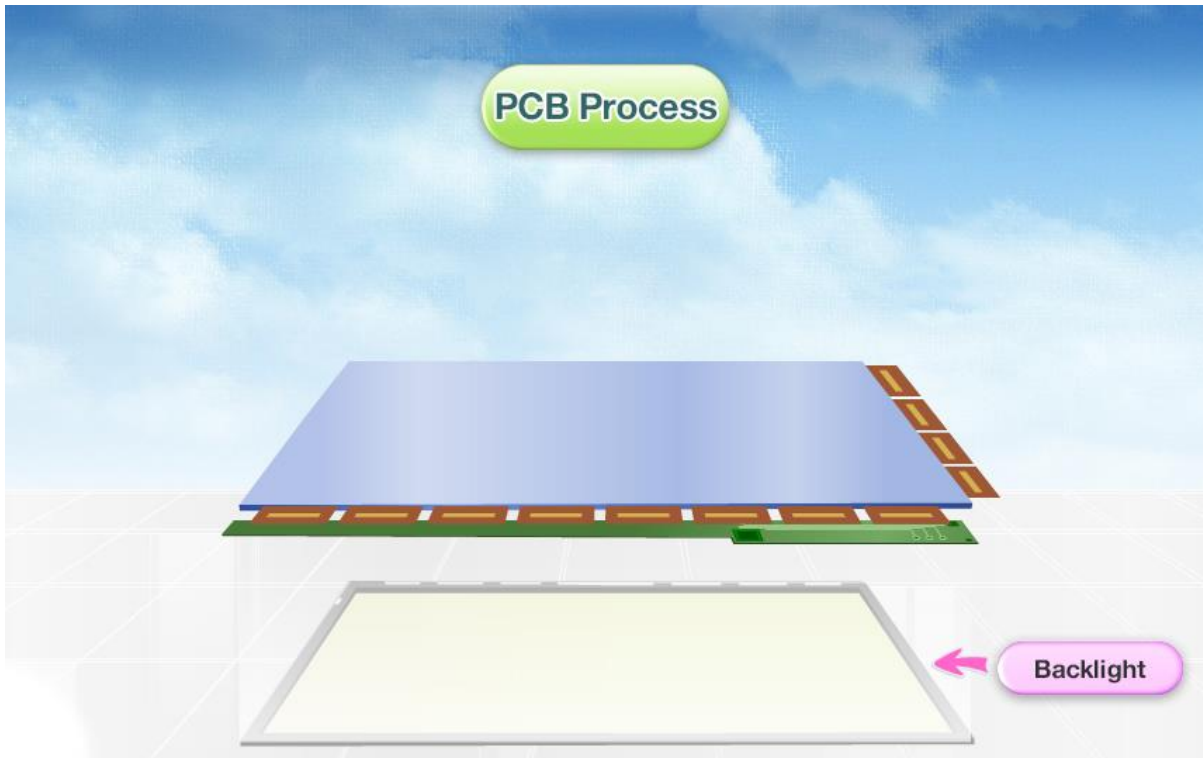
To equivocate this to the tab process, as in the TAB process, we first apply an adhesive tape

(ACF: Anisotropic Conductive Panel) on the surface of the PCB. Making sure that the films are placed in their appropriate positions on the PCB, we apply high heat and pressure to make sure the ACF adheres to the PCB.

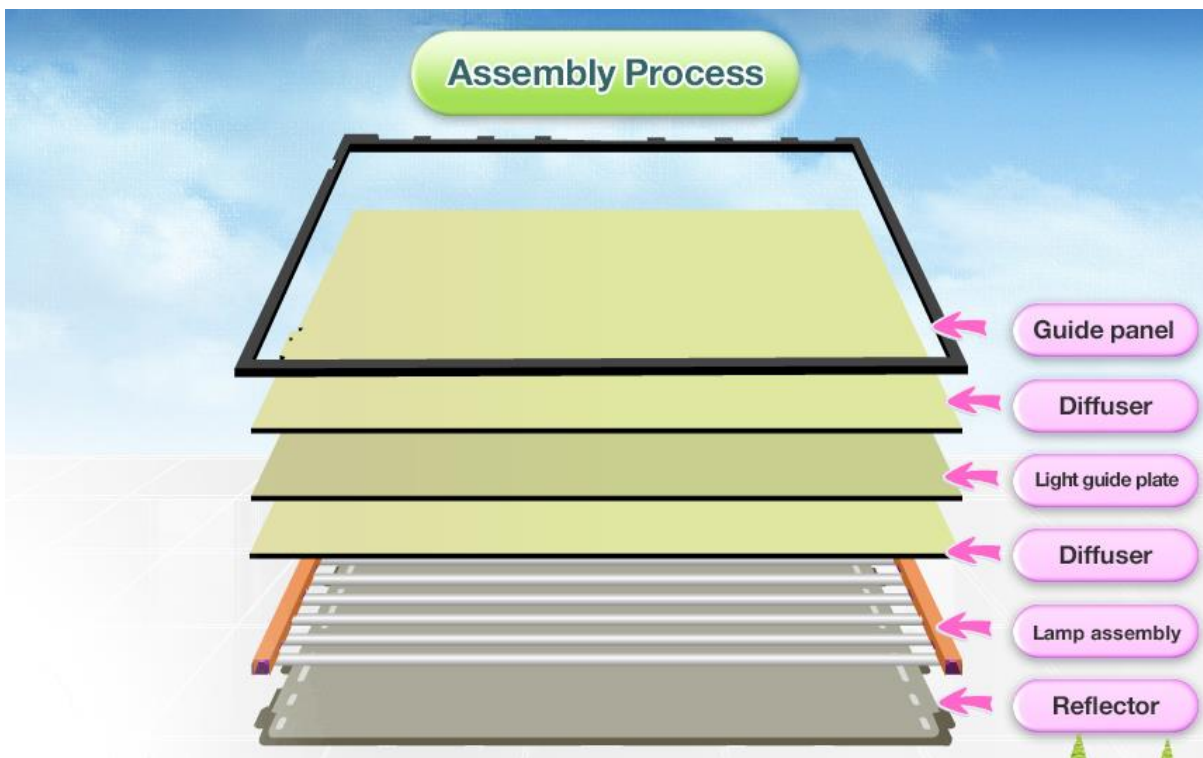


Since humidity may build up between the TFT board and the color filter, crevice, is the edges of the color filter are filled with silicone. After the panel is tested for its proper functioning, it is passed on to the next process.

Assembly Process

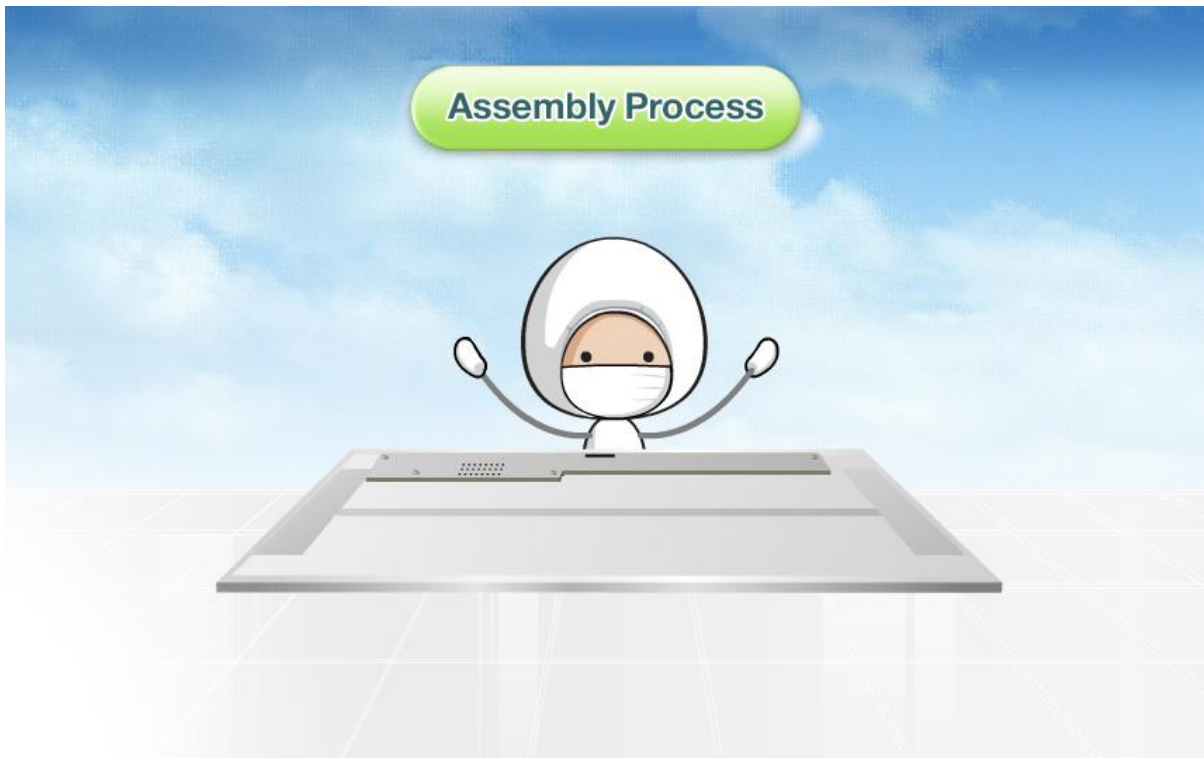


Because TFT-LCD panels cannot give off light on their own, they need a backlight installed to do this for them. Let's look into the constituents of the backlight.



The backlight consists of a sheet of reflector, which reflects light in the direction of the light guide plate; the lamp assembly where the light originates; the diffuser that literally distributes the light evenly on the surface of the reflector; another diffuser; and the guide panel that

fixes the sheets together and protects them from external shocks.



The panel that has gone through the PCB process is called the board assembly. We mount this board assembly on the backlight and fold the PCB back. A top case is placed to fix the panel and the backlight in place and to protect them from external shock. After attaching the film to protect the screen of the panel and assemble a protective case for the PCB, we finally have a TFT-LCD module.

Aging Process and the Final Checkup

Aging Process and the Final Checkup



The TFT-LCD module still needs to go through a series of verification process for quality assurance, starting with aging process and the final-checkup. First, the screen needs to be checked for its proper performance. Then enters the aging process in which it receives electronic signals for a set amount of time under high temperature condition. This process allows the liquid crystal to stabilize and enhances the reliability of the product. Lastly, after several checkups, the product is finally guaranteed of its quality.



After the final checkup of the module, we run a visual checkup to make sure that the lines to the backlight are well connected and the top case is assembled properly. After we run another final checkup to ensure the perfect quality, the final product is wrapped in a electrostatic protective material and boxed to be delivered to customers all around the world.
