TFT - LCD Display

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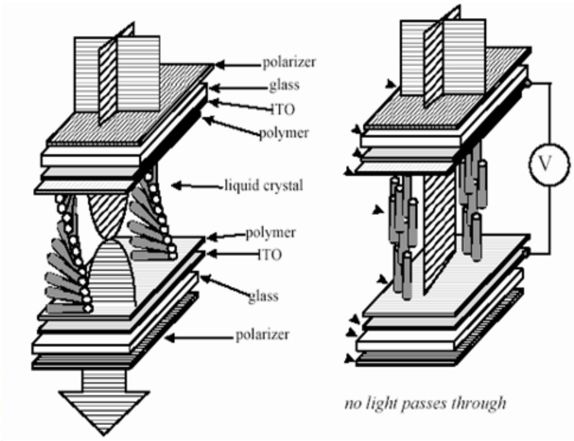
Most displays in current use employ cathode ray tube (CRT) technology similar to that used in most television sets. The CRT technology requires a certain distance from the beam projection device to the screen to function. Using other technologies, displays can be much thinner and are known as flat-panel displays. Flat panel display technologies include light-emitting diode (LED), liquid crystal display (LCD) and gas plasma. LED and gas plasma work by lighting up display screen positions based on voltages at different grid intersections. LCDs are categorized as non-emissive display devices, in that respect they do not produce any form of light. LCDs either pass or block light that is reflected from an external light source or provided by a back/side lighting system. LCDs require far less energy than LED and gas plasma technologies and are currently the primary technology for notebook and other laptop computers.

LCD Structure

LCD devices consists of a nematic liquid crystal sandwiched between two plates of glass. In detail, first a sheet of glass is coated with a transparent conducting metal oxide film which acts as an electrode. This film can be patterned to form the rows and columns of a passive matrix display or the individual pixels of an active matrix display. These electrodes are used to set up the voltage across the cell necessary for the orientation transition.

Next, a polymer alignment layer is applied. This layer undergoes a rubbing process which leaves a series of parallel microscopic grooves in the film. These grooves help align the liquid crystal molecules in a preferred direction, with their longitudinal axes parallel to the grooves. The same sheet of glass is prepared and once the display has been filled with liquid crystals, crossed polarizers are applied to the exposed glass surfaces.

When an electric field is applied between the two electrodes, liquid crystal molecules will react in such a way as to control light passage.



Introduction to liquid Crystal

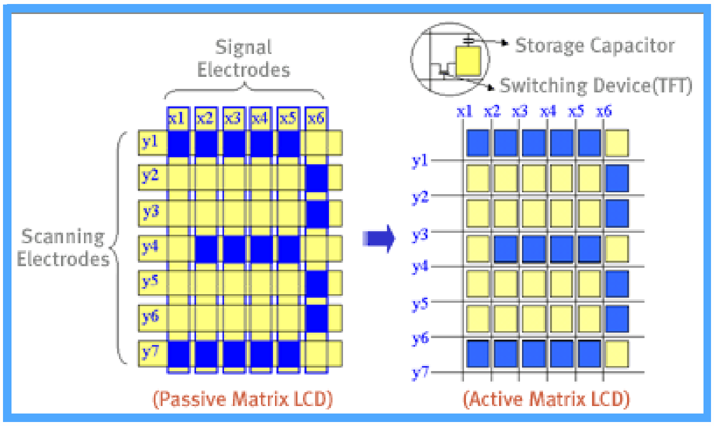
The molecules forming liquid crystals are often characterized by cigar-shaped or elongated molecules. The direction of the elongation defines the long axis of the molecules. The essential properties of a liquid crystal are its optical and electromagnetic anisotropy. The manifestation of this property at the molecular level is that the long axis of the molecules tend to align in a preferred direction, that is, they have orientational order. Depending on the type of this orientational order, there are a number of distinct phases of liquid crystals materials : nematic, smectic and cholesteric.

For displays applications, the most useful are the nematic and twisted nematic phases. The nematic phase is characterized by long-range orientational order. The long molecular axes possess a preferred orientation, so that on the average they are positioned parallel to the director. The director field is easily distorted by electromagnetic fields or by surfaces that have been properly prepared.

By introducing a nematic liquid between two surfaces with the alignment preparation perpendicular to each other, a peculiar situation is achieved where the director is seen to rotate in a regular fashion from one plate to another as one progresses along the twist axis. This is known as the 90 degree twisted nematic phase that is widely used for liquid crystal displays.

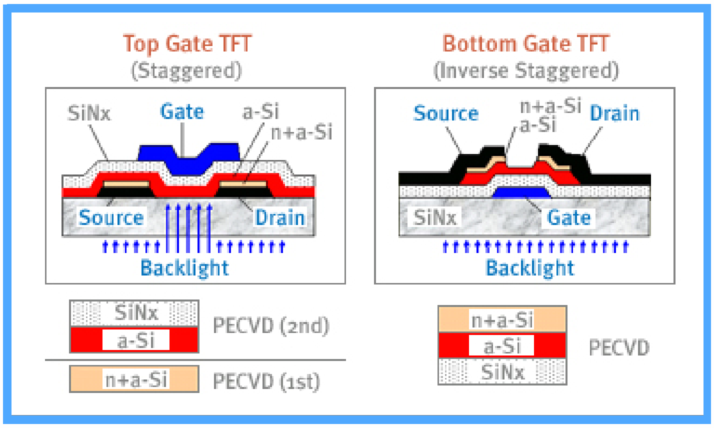
Display addressing

An LCD is made with either a passive matrix or an active matrix display grid. The active matrix LCD is also known as thin film transistor (TFT) display. The passive matrix LCD has a grid of conductors with pixels located at each intersection in the grid. A current is sent across two conductors on the grid to control light for any pixel. An active matrix has a transistor located at each pixel intersection, requiring less current to control the luminance of a pixel. For this reason, the current in an active matrix display can be switched on and off more frequently, improving the screen refresh time.



TFT device design

The most common TFT design called inverse staggered structure is presented below. This structure presents the advantages of a simple fabrication process and a high electron mobility.
In the TFT array fabrication process the first step consists of gate and storage-capacitor electrodes construction with 2000-3000 A of a metal such as aluminum, chromium, tantalum or tungsten layer deposition. Then a triple layer of silicon nitride and amorphous silicon is deposited using PECVD.

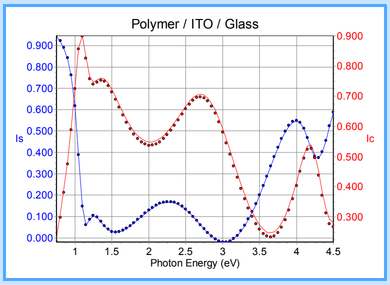


Full TFT-LCD device characterization

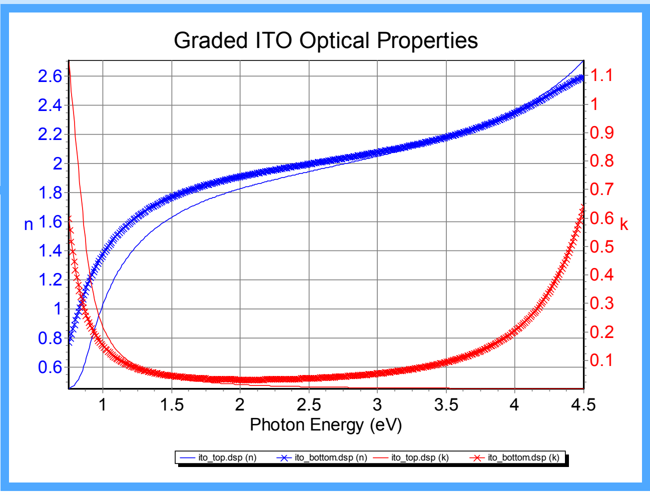
Non destructive characterization of the different parts of the TFT-LCD device was successfully carried out by Spectroscopic Ellipsometry (SE). The ellipsometric data were collected at an angle of incidence of 70° using the Jobin Yvon UVISEL NIR (260-1700 nm).

The UVISEL Spectroscopic Phase Modulated Ellipsometer is a unique instrument that provides significant advantages for display applications when compared to conventional ellipsometers. Its technology is the most suitable for accurate thin film measurement on transparent substrates as the software includes advanced capabilities for automatic correction of backside reflections.

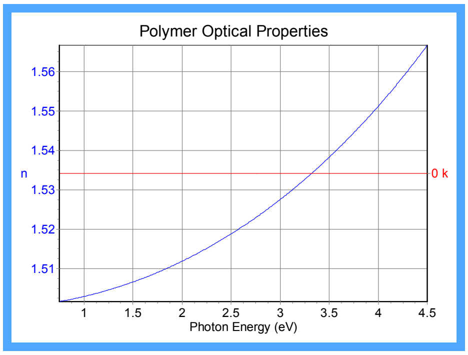
Polymer	210 Å
ITO	1280 Å
Glass	



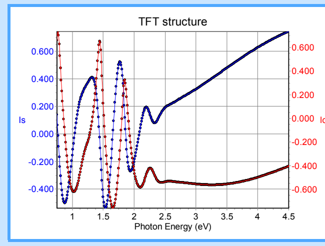
The 1st part of the device consists of a glass substrate covered with an ITO layer and a polymer layer.
ITO is a semi-transparent conducting material which exhibits absorption in the FUV and NIR and is known to be inhomogeneous due to the deposition method or post-treatments. A graded layer model has to be taken into account in the model.
Refractive index and thickness of each layer were accurately characterized from 0.75 to 4.5 eV.



Spectroscopic Ellipsometry

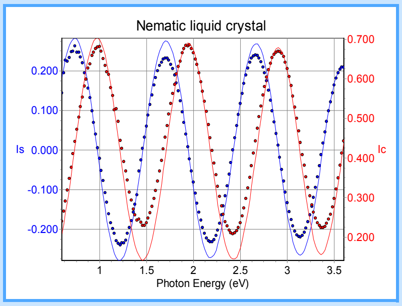


Roughness	24 Å
n-a-Si	514 Å
a-Si	1838 Å
Sin	4095 Å
Glass	0.7 mm

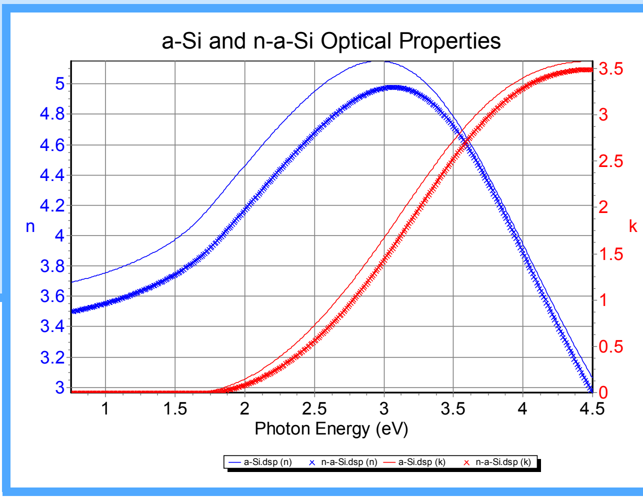


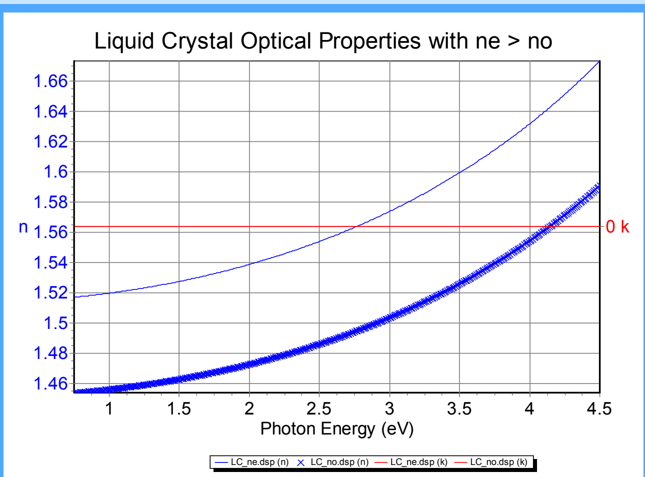
Characterization of the TFT structure is presented below.
Optical constants depend strongly on process conditions. Ellipsometry is sensitive to the effect of dopants as it induces changes in optical properties.

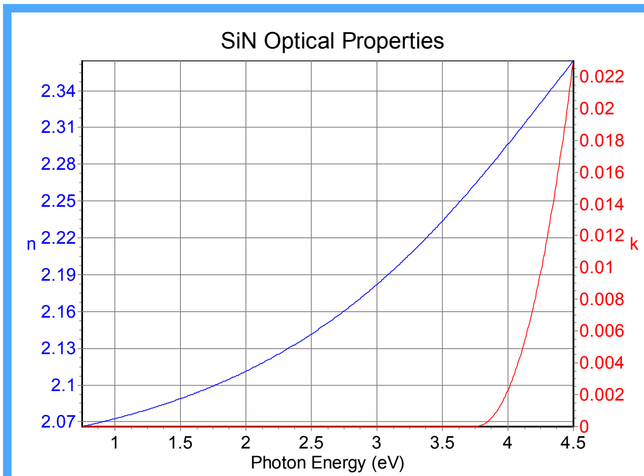
Glass	1 mm
Liquid Crystal	20 µm
Glass	1 mm



The second part of the device consists of a nematic liquid crystal confined between two plates of glass. The characterization of this structure requires advanced modeling functions such as anisotropy and double backside correction.
The liquid crystal is homeotropic and presents uniaxial anisotropy with N axis (perpendicular to the sample plane).







Conclusion

Phase Modulated Spectroscopic Ellipsometry is an excellent technique for the highly accurate characterization of complete TFT-LCD device. The technique allows the determination of film thickness, optical properties but also more complex properties such as graded or anisotropic layers and effect of dopants.
In the flat panel industry the pressure to reduce manufacturing costs is and reliable metrology tools are required to control the different steps of the process. Spectroscopic ellipsometry is a non destructive technique which presents advanced capabilities and proven reliability tailored for qualification and on-line production control.

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