

Liquid Crystal Displays

Part 1: The glass substrate

What is a Liquid Crystal Display?

- Liquid Crystal Display = “LCD”
- Display has special glass/liquid crystal structure
 - Liquid crystal between 2 thin glass layers
 - Crossed polarizers to control light passage produces black letters on white background
- Electrodes in the glass change liquid crystal structure to let light pass or not

- First let us consider the type of glass needed for an LCD display
 - Very light and thin
 - As transparent as possible
 - Capable of patterning, etching

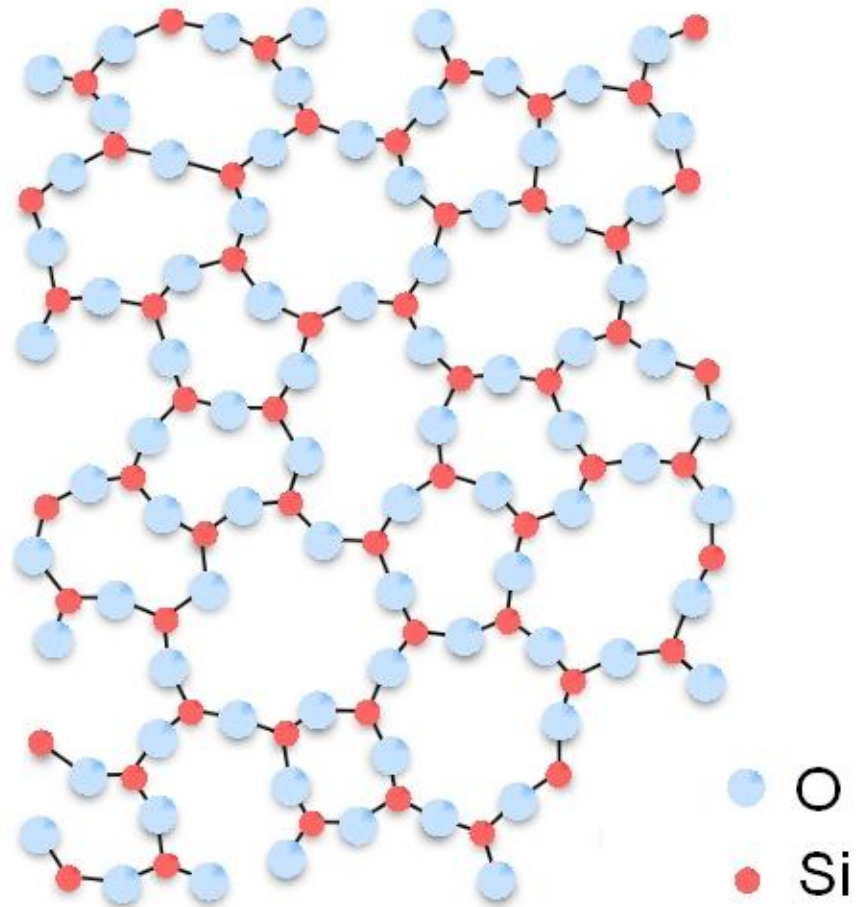
What is Glass?

- Non-crystalline solid
 - “Amorphous” with no long range order among the atoms making up the constituents
 - Glass formation called “vitrification”
- Usually hard, brittle and transparent
- Principal ingredient—Silica
 - Other ingredients added to enhance properties, change melting temperature, etc.

Glass Formation

- Glass forms when a system has a complex-enough structure or the cooling rate is rapid:
 - Difficult to organize the structure on rapid cooling
 - Each system has a “glass transition temperature” or T_g below which the system becomes rigid
 - Even metal alloys can become glassy if cooled fast enough
 - Many polymers are glassy
- Typical structure of a glass (silica or SiO_2) shown on the following slide from Wikipedia:

Structure of Silica



Types of Glass Products

- Plate glass—used in windows
- Blown glass—art glass
- Tempered glass—heat treated for properties
- Safety glass—laminated with plastic
- Electrochromic glass
- E-glass
- Liquid crystal glass (LCD glass)

- How do we make this glass that needs to be
 - Very light and thin?
 - As transparent as possible?
 - Capable of patterning, etching?
- Good example: video from Corning
 - http://www.corning.com/r_d/technology_exploration/consumer_electronics.aspx
 - Choose “Window on Information,” English

Typical LCD Glass Applications

- Computer monitors
- I-pods, calculators, clocks, watches
- Flat screen television sets
- Instrument panels

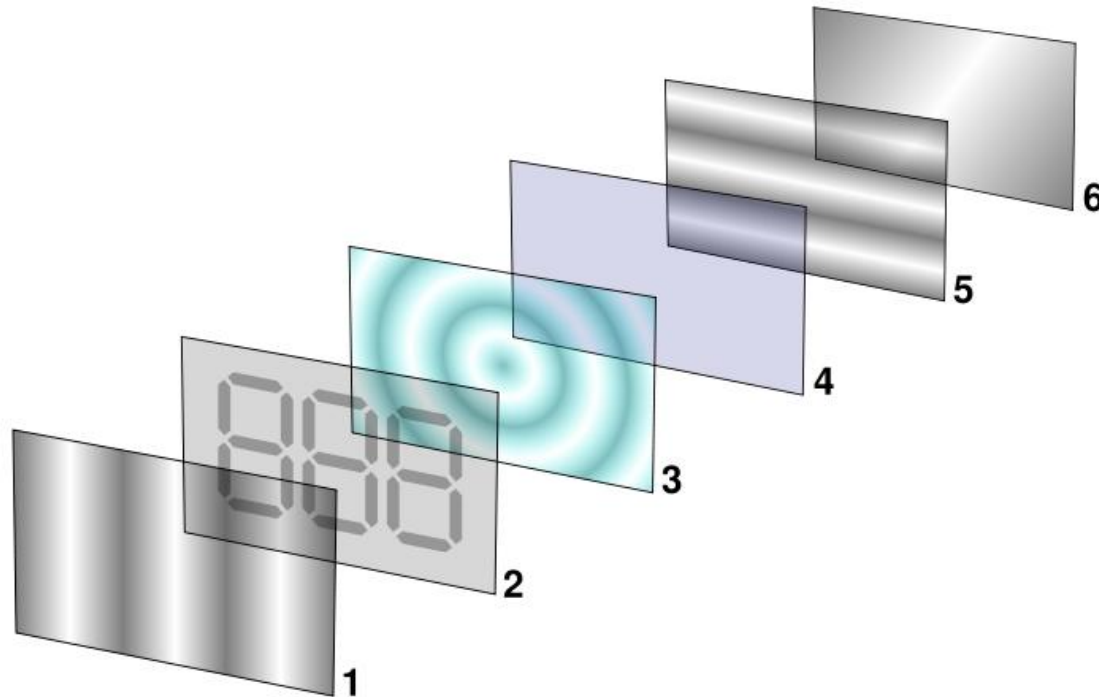
- Color requires additional sub-electrodes and color filters

Typical Active Matrix LCD/Glass Structure

- Top thin glass layer
 - Polarizing film in vertical direction
 - Etched electrodes, color pixels and vertical lines in the glass
- Liquid crystal layer
- Bottom thin glass layer
 - Etched thin film transistor (TFT) array and horizontal lines in glass
 - Polarizing film in horizontal direction

Typical LCD Layer Structure

from Wikipedia



Layer description (from Wikipedia)

1. Polarizing filter film with a vertical axis to polarize light as it enters.
2. Glass substrate with transparent indium tin oxide electrodes and color subpixels. Electrode shape determine the shapes that will appear when the LCD is turned ON. Smooth vertical ridges etched on the glass surface to match polarization.
3. Twisted nematic liquid crystal.
4. Glass substrate with TFT layer and horizontal ridges to line up with the horizontal filter.
5. Polarizing filter film with a horizontal axis to block/pass light; light passes if liquid crystal has changed the polarization.
6. Reflective surface to send light back to viewer. (In a backlit LCD, this layer is replaced with a light source.)

Color Filter

- Color controlled by subpixels with red, blue and yellow filters
- Control and variation of voltage produces over 256 shades
- Combining the 3 filters (256 each) with additive coloration can produce over 16 million shades and colors

Nematic Liquid Crystal

- This molecular liquid modifies the polarization of light waves depending on the applied electric field.
 - With no applied field, the LC produces a 90 degree shift in polarization.
 - Light transmission varies with the applied field, and an increasing electric field produces varying amounts of light transmission, from 100% to 0.
- More on liquid crystals in the next lesson

Lesson Summary

- Glass is a non-crystalline solid
- LCD glass is made in a special process
- LCDs contain a variety of essential components, including
 - Filters
 - Electronics
 - Nematic liquid crystals
- Today, LCDs can be found in all types of electronics