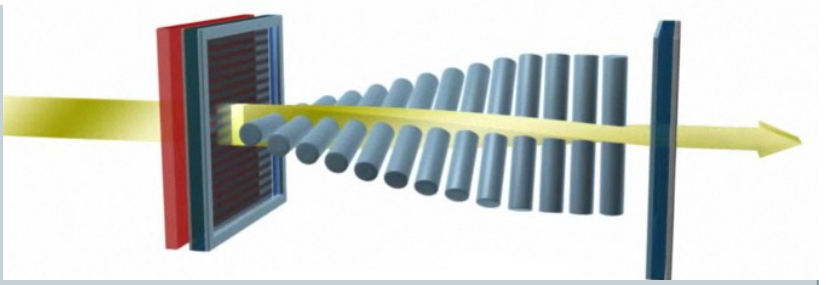
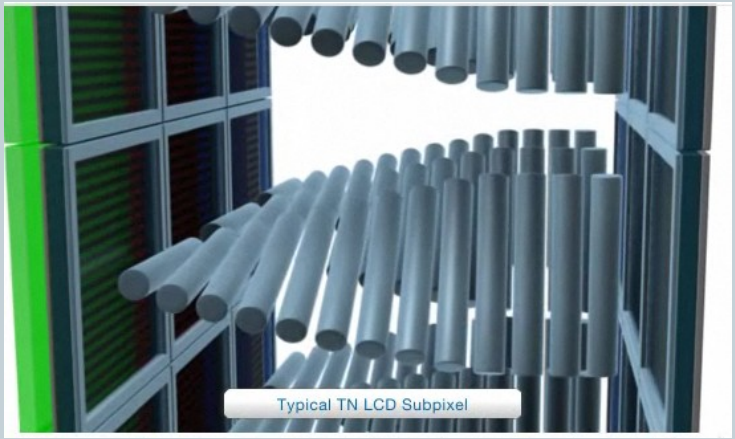
Semiconductor Diode

LCD (Liquid Crystal Display)

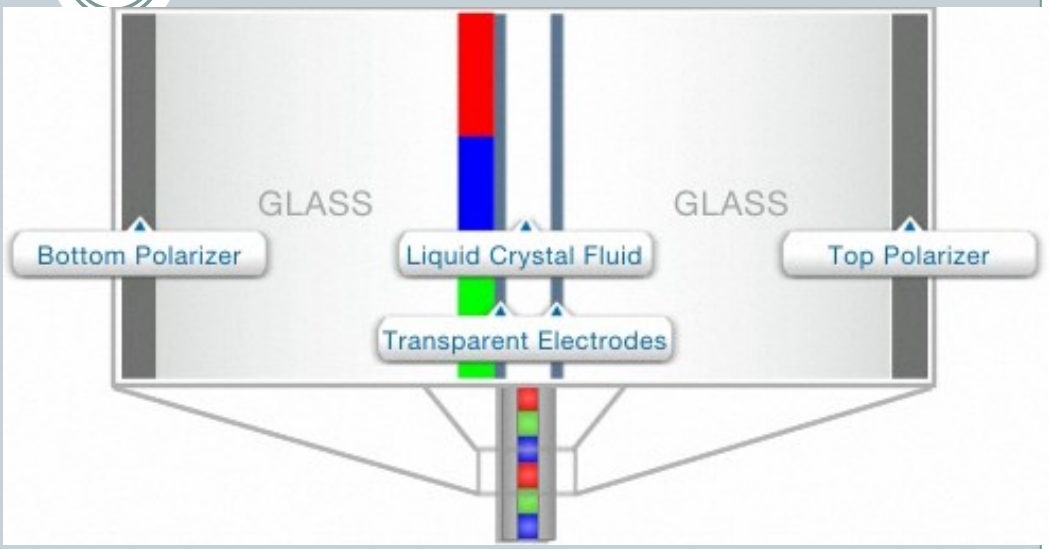
- LCD Panel is based on
  - A light valve for each pixel that turn the light on, off, or an intermediate level.
- Grid of such light valve for the LCD display panel.
- A back light and display enhancement films create the illumination.

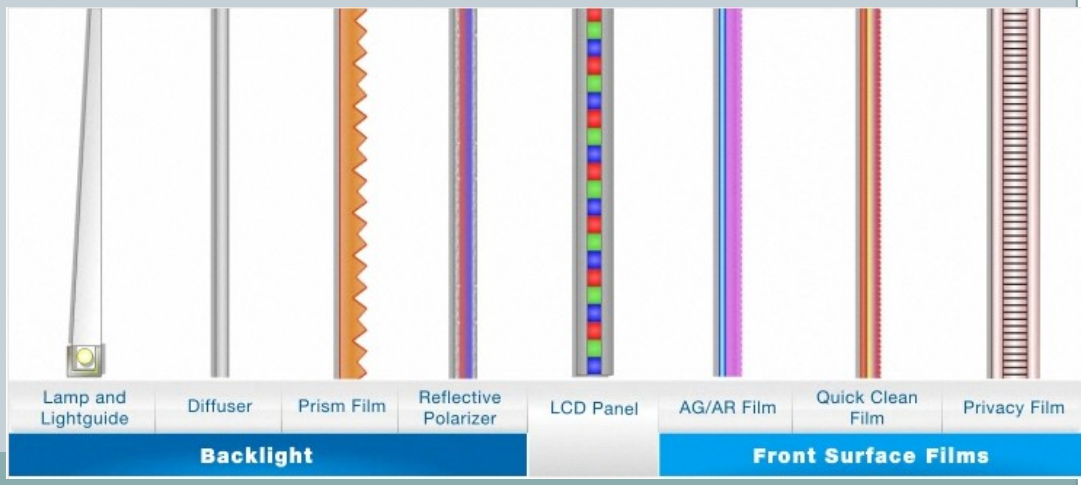




LCD-Display

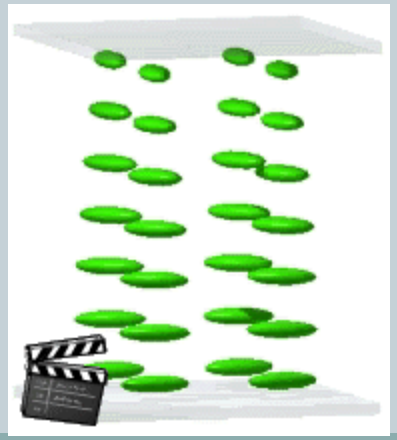
- Applying voltage to the electrodes changes the level of illumination in each sub-pixel
- The panel is sandwiched between
  - Front surface films to enhance display property
  - Backlight

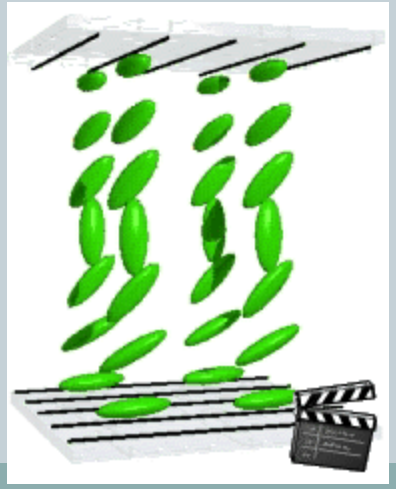




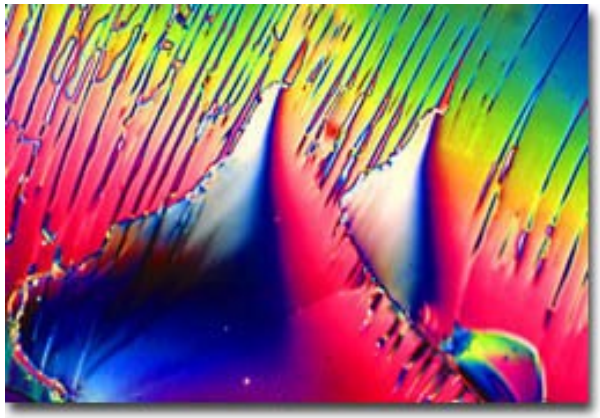
1. What's Liquid Crystals (LC)

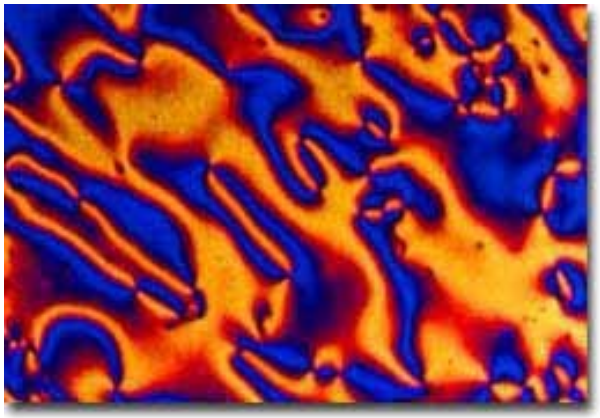
- intermediary substance between a liquid and solid state of matter.
  e.g. soapy water
- light passes through liquid crystal changes when it is stimulated by an electrical charge.

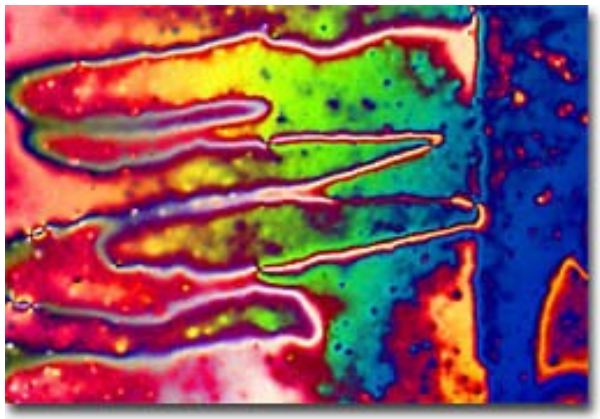


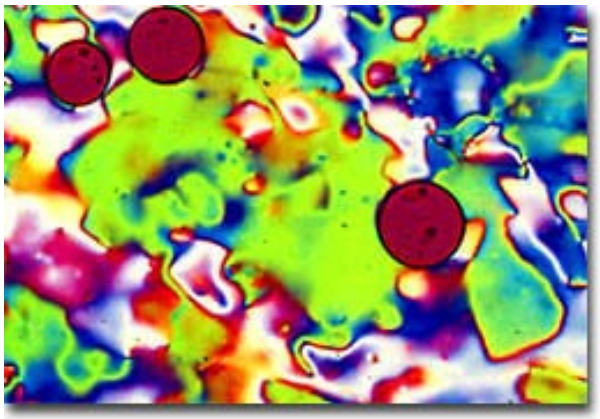


Examples of LCs









2. Introduction to Liquid Crystal Displays

- Consists of an array of tiny segments (called pixels) that can be manipulated to present information.
- Using polarization of lights to display objects.
- Use only ambient light to illuminate the display.
- Common wrist watch and pocket calculator to an advanced VGA computer screen

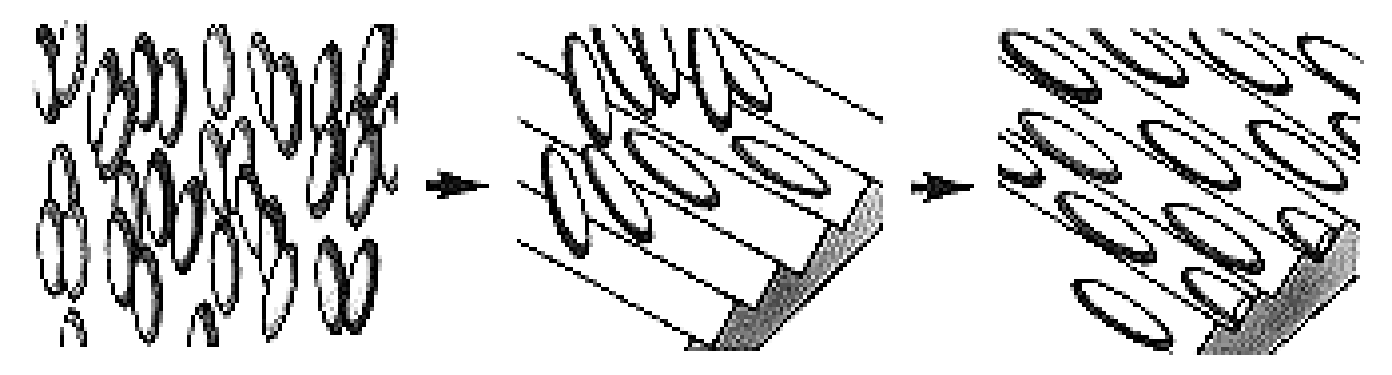
Different types of LCDs

Passive Matrix LCDs (AMLCD) and Active Matrix LCDs (AMLCD)

- Passive Twisted Nematic Displays (TNLCD)
- Super Twisted nematic LCD (STNLCD)
- Thin Film Transistor LCD (TFT LCD)
- Reflective LCD
- Rear Projection LCD

3. Operating Principle

- The parallel arrangement of liquid crystal molecules along grooves
- When coming into contact with grooved surface in a fixed direction, liquid crystal molecules line up parallel along the **grooves**.

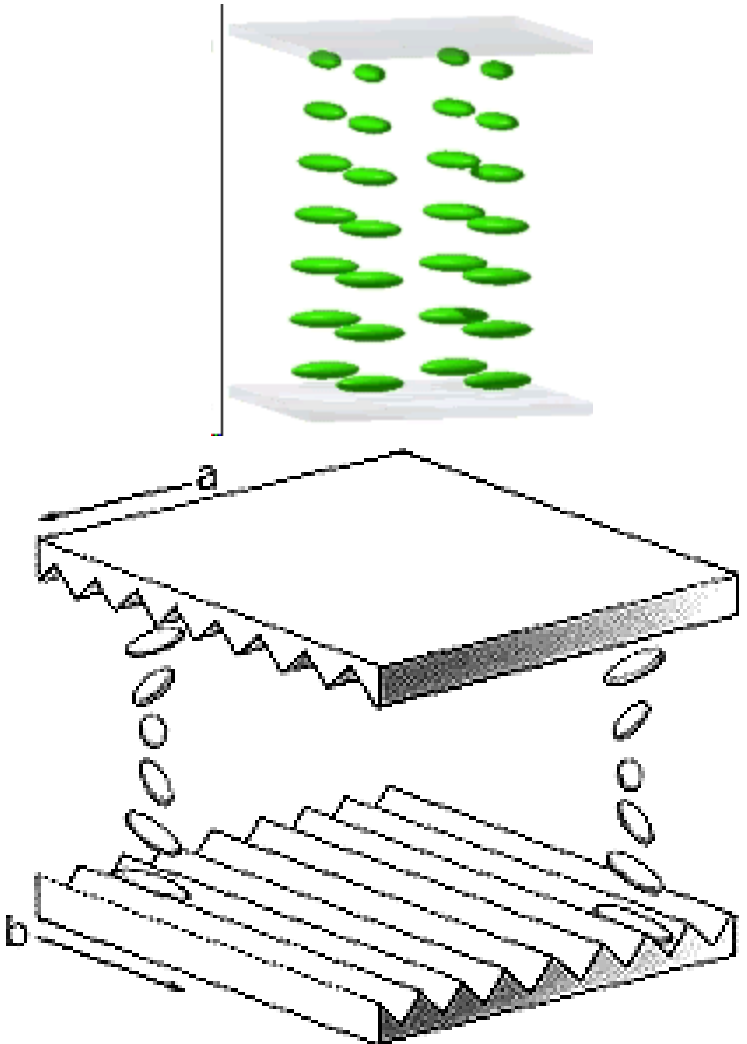


3. Operating Principle

Molecules movement

Offline (no voltage is applied)

- Along the upper plate : Point in direction 'a'
- Along the lower plate : Point in direction 'b‘
- Forcing the liquid crystals into a twisted structural arrangement. (Resultant force)

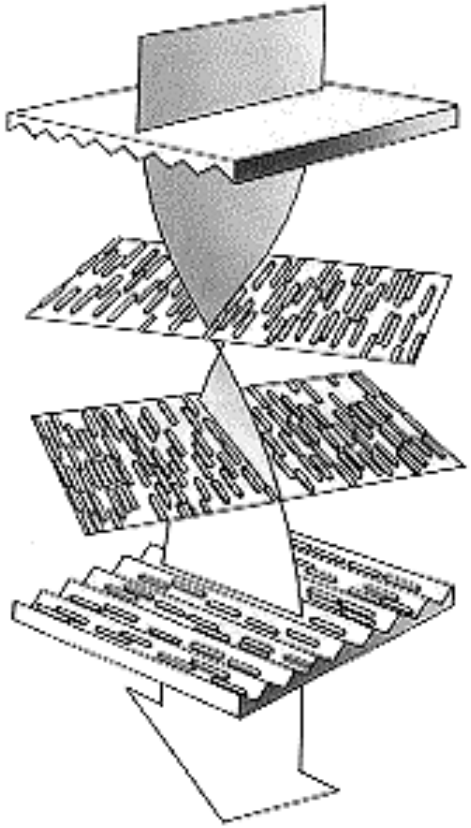


3. Operating Principle

Light movement

Offline (no voltage is applied)

- Light travels through the spacing of the molecular arrangement.
- The light also "twists" as it passes through the twisted liquid crystals.
- Light bends 90 degrees as it follows the twist of the molecules.
- Polarized light pass through the analyzer (lower polarizer).

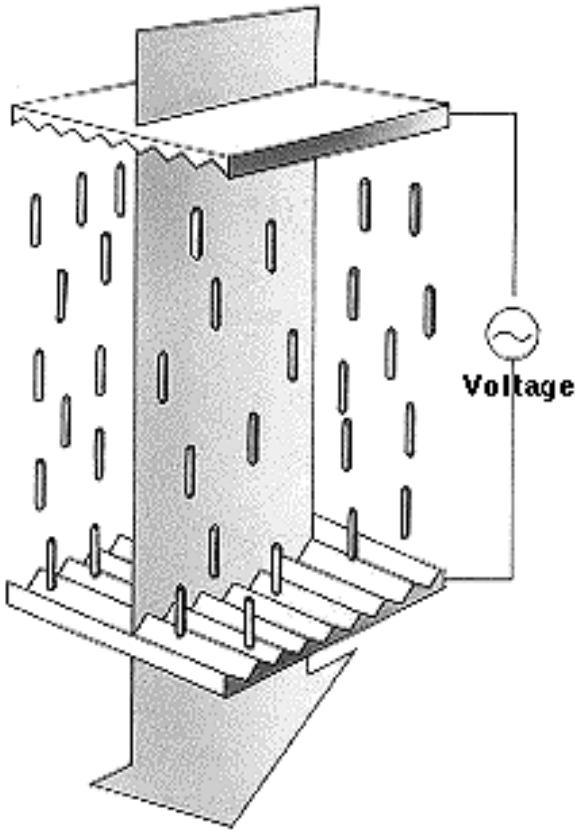


3. Operating Principle

Molecules movement

Online (voltage is applied)

- Liquid crystal molecules straighten out of their helix pattern
- Molecules rearrange themselves vertically (Along with the electric field)
- No twisting thoughout the movement
- Forcing the liquid crystals into a straight structural arrangement. (Electric force)

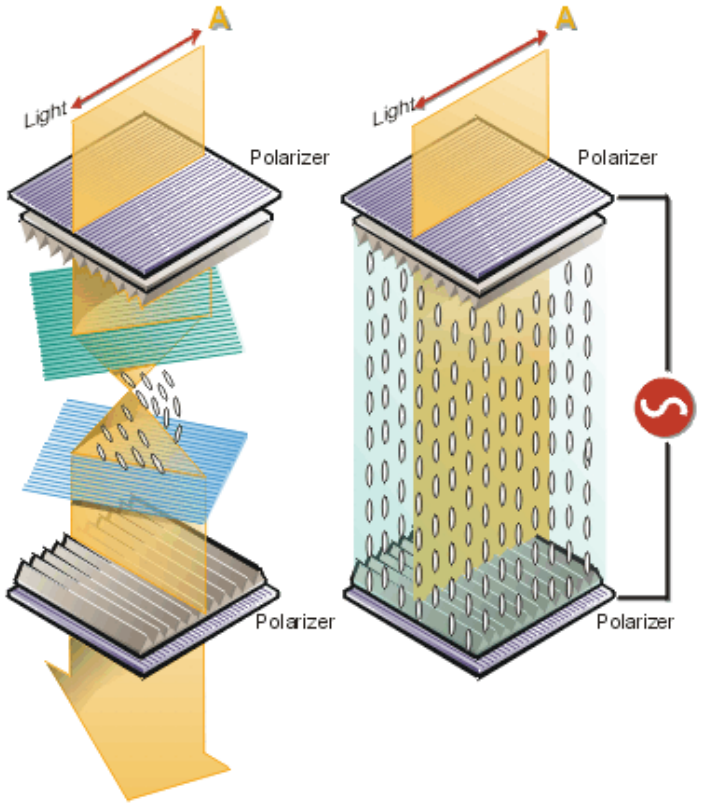


3. Operating Principle

Light movement

Online (voltage is applied)

- Twisted light passes straight through.
- Light passes straight through along the arrangement of molecules.
- Polarized light cannot pass through the lower analyzer (lower polarizer).
- Screen darkens.

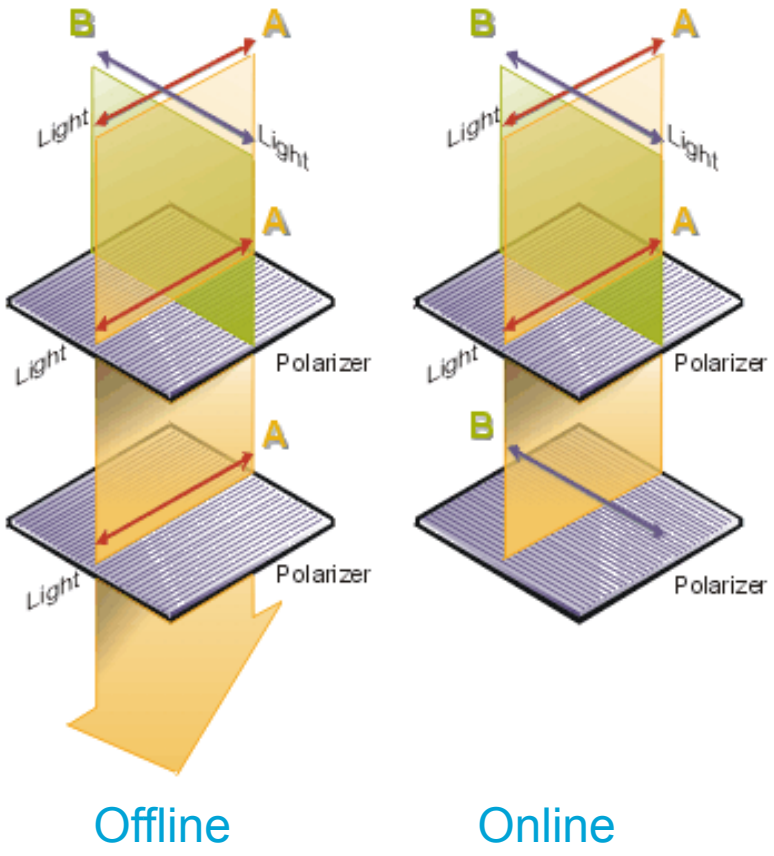


3. Operating Principle

Sequences of offline and online mode

Offline

1. Surrounding light is polarized on the upper plate.
2. Light moves along with liquid crystals and twisted at right angle.
3. Molecules and lights are parallel to the lower analyzer.
4. Light passes through the plate.
5. Screen appear transparent.

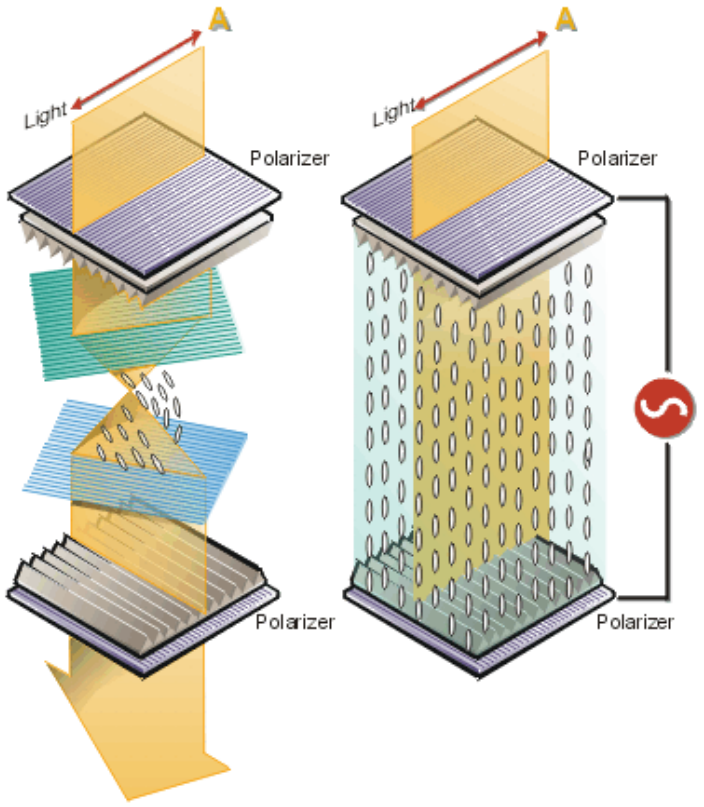


Offline Online

3. Operating Principle

Sequences of offline and online mode

1. Surrounding light is polarized on the upper plate.
2. Light moves along with liquid crystals which moves straight along the electric field.
3. Molecules and lights are perpendicular to the lower analyzer.
4. Light cannot pass through the plate.
5. Screen appear dark.

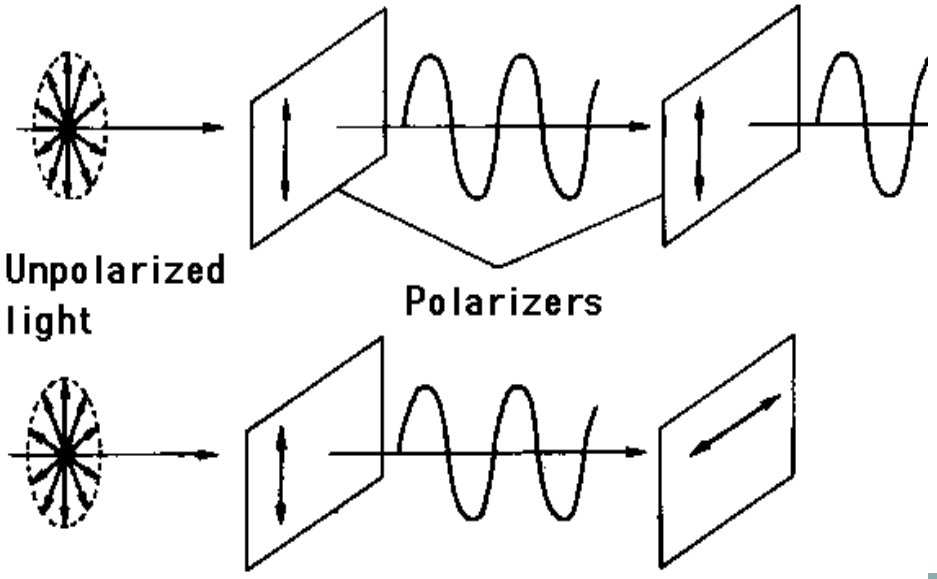


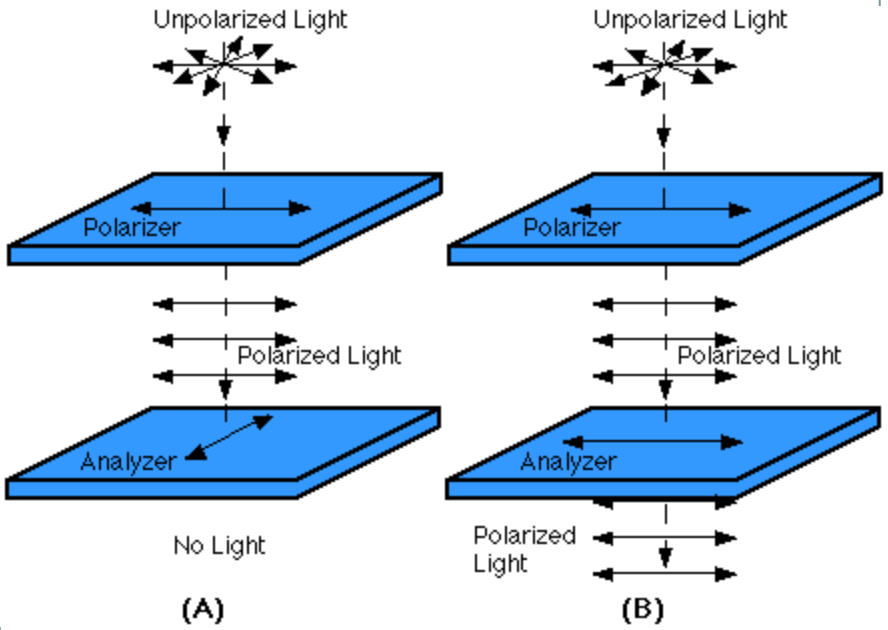
Offline Online

3. Operating Principle

Polarization of light

- When unpolarized light passes through a polarizing filter, only **one plane of polarization is transmitted**. Two polarizing filters used together transmit light differently depending on their relative orientation.



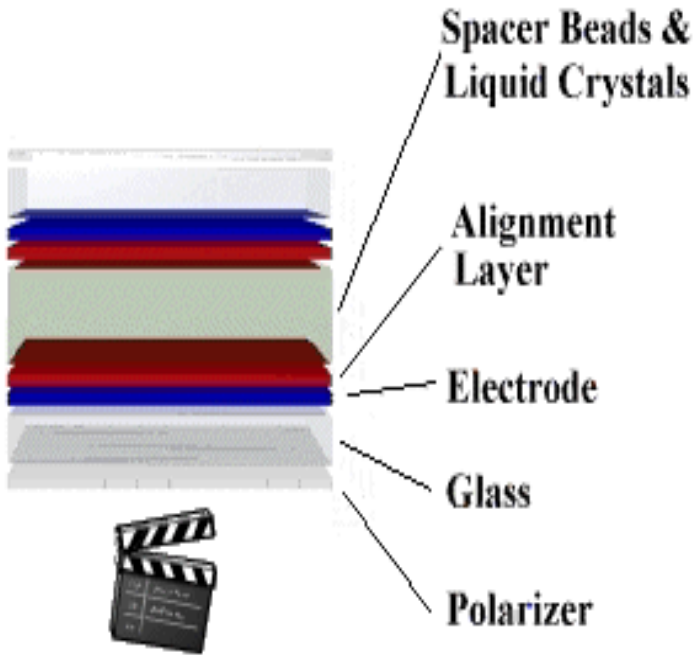


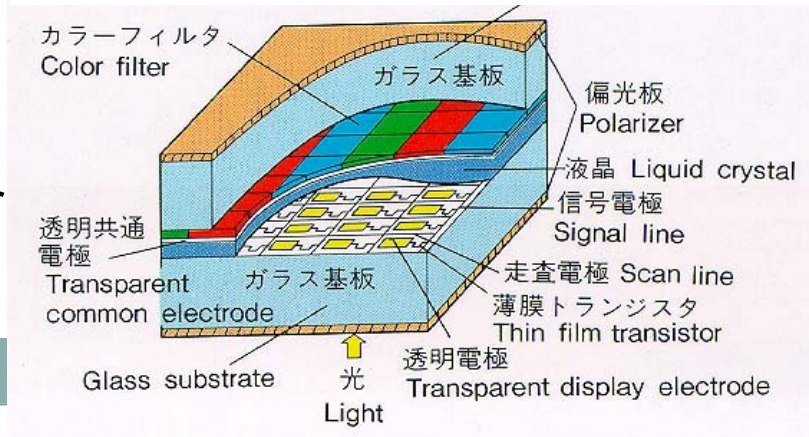
Online Offline

3. Operating Principle

Construction of Liquid Crystal Display

- Two bounding plates (usually glass slides), each with a **transparent conductive coating** (such as indium tin oxide) that **acts as an electrode**;
- A polymer alignment layer : undergoes a rubbing process as grooves.
- **Spacers** to **control the cell gap precisely**;
- Two crossed polarizers (the **polarizer** and the **analyzer**);
- Polarizers are usually perpendicular to each other.





3. Operating Principle

Properties of LCD Display

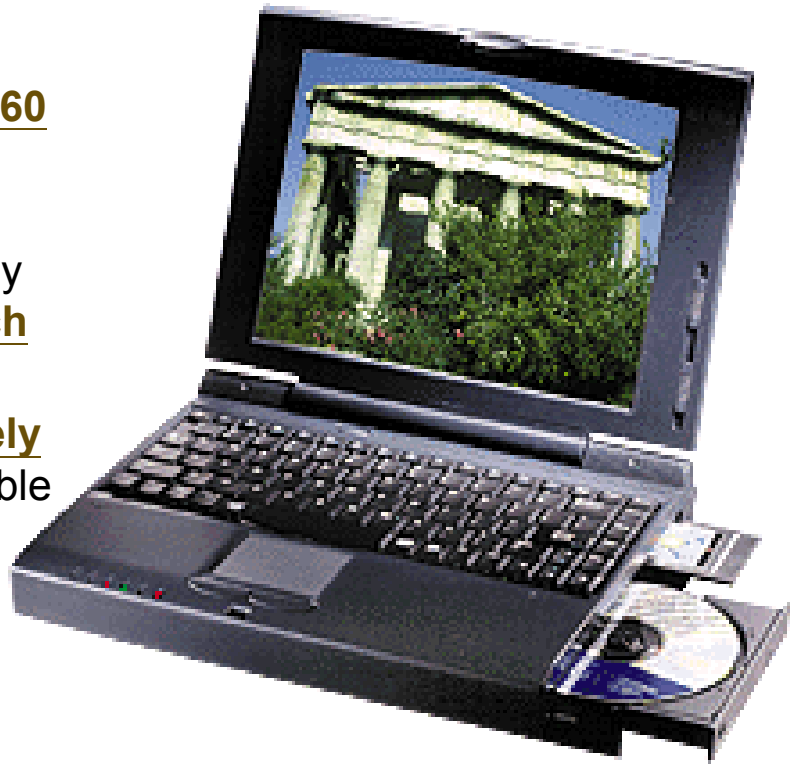
- Small footprint (approx 1/6 of CRT)
- Light weight (typ. 1/5 of CRT)
- power consumption (typ. 1/4 of CRT)
- Completely flat screen - no geometrical errors
- Crisp pictures - digital and uniform colors
- No electromagnetic emission
- Fully digital signal processing possible
- Large screens (>20 inch) on desktops
- High price (presently 3x CRT)
- Poor viewing angle (typ. 50 degrees)
- Low contrast and luminance (typ. 1:100)
- Low luminance (typ. 200 cd/m2)

Maximum luminosity : 50% of CRT as 50% of light is blocked by the upper polarizer.

3. Operating Principle

Advantage of LCD over CRT

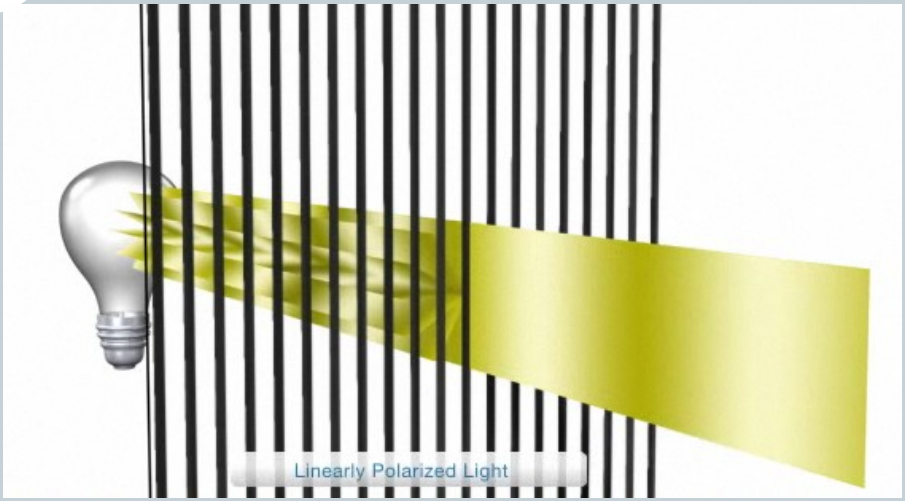
- **Smaller size**—AMLCDs occupy approximately **60 percent less space** than CRT displays—an important feature when office space is limited.
- **Lower power consumption**—AMLCDs typically **consume about half the power** and **emit much less heat** than CRT displays.
- **Lighter weight**—AMLCDs **weigh approximately 70 percent less** than CRT displays of comparable size.
- **No electromagnetic fields**—AMLCDs **do not emit electromagnetic fields** and are not susceptible to them. Thus, they are suitable for use in areas where CRTs cannot be used.
- **Longer life**—AMLCDs have **a longer useful life** than CRTs; however, they may require replacement of the backlight.



Maximum luminosity : 50% as 50% of light is blocked by the upper polarizer.

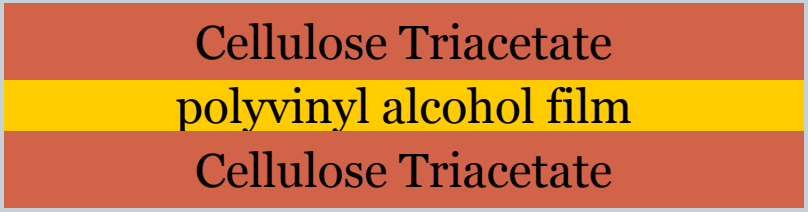
Linear Polarized Light

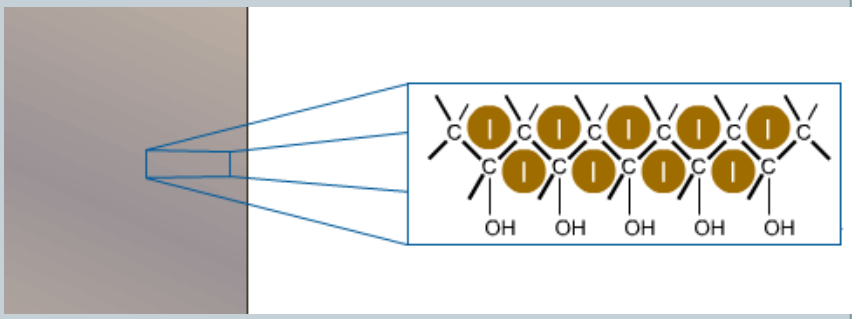
- Light usually vibrates in all direction
- A linear polarized light limit the vibration to one direction
- It absorbs the component of light that vibrate in all other direction.
- LCD require light to vibrate in one direction



Iodine Based Polarizer

- Is the most common polarizer
- It is made by
  - Stretching a cast polyvinyl alcohol film (PVA) to align the iodine in turn.
  - Staining it with iodine
  - The stained PVA laminated between two slices of cellulose triacetate.
- The cellulose triacetate
  - Provide physical rigidity
  - Some degree of heat and humidity protection

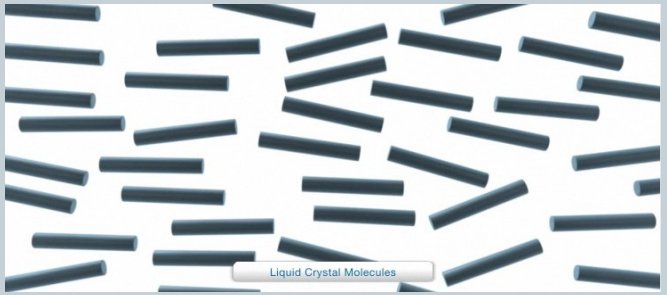


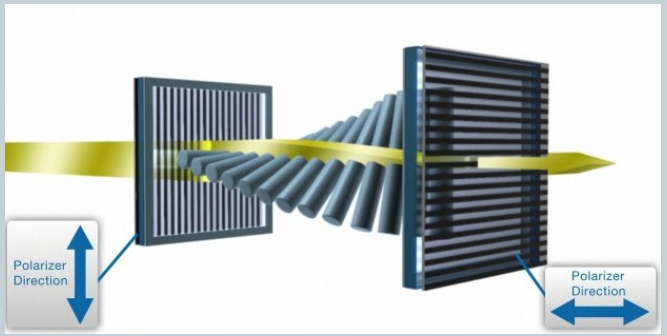


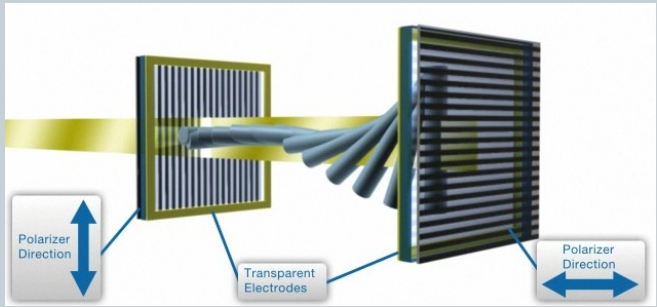
polyvinyl alcohol film

About Liquid Crystal

- Liquid crystal molecules can move freely while maintaining their orientation.
- It align itself to a polyimide film to the inside of a panel glass.
- When the two glass panels are not aligned the liquid crystal twists accordingly.
- The liquid crystal will also align to electric field.







Light Path

- The light passes through the polarizer.
- The voltage applied to the electrodes controls the liquid crystal orientation
- The liquid crystal orientation controls the rotation of the incoming polarized light.
- Color filters are used in color LCD, where each color sub-pixel is controlled individually