

LIQUID CRYSTAL DISPLAY

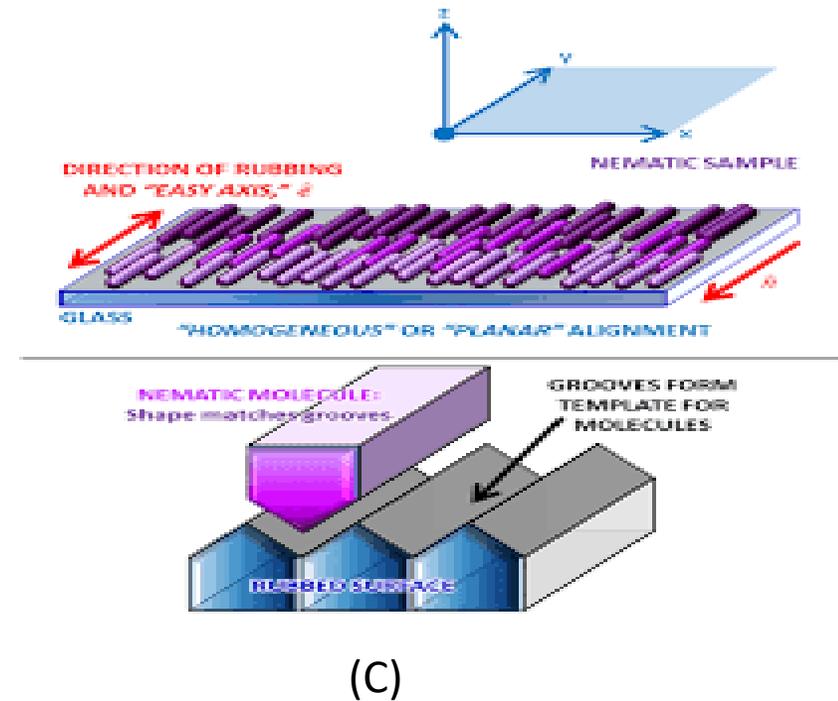
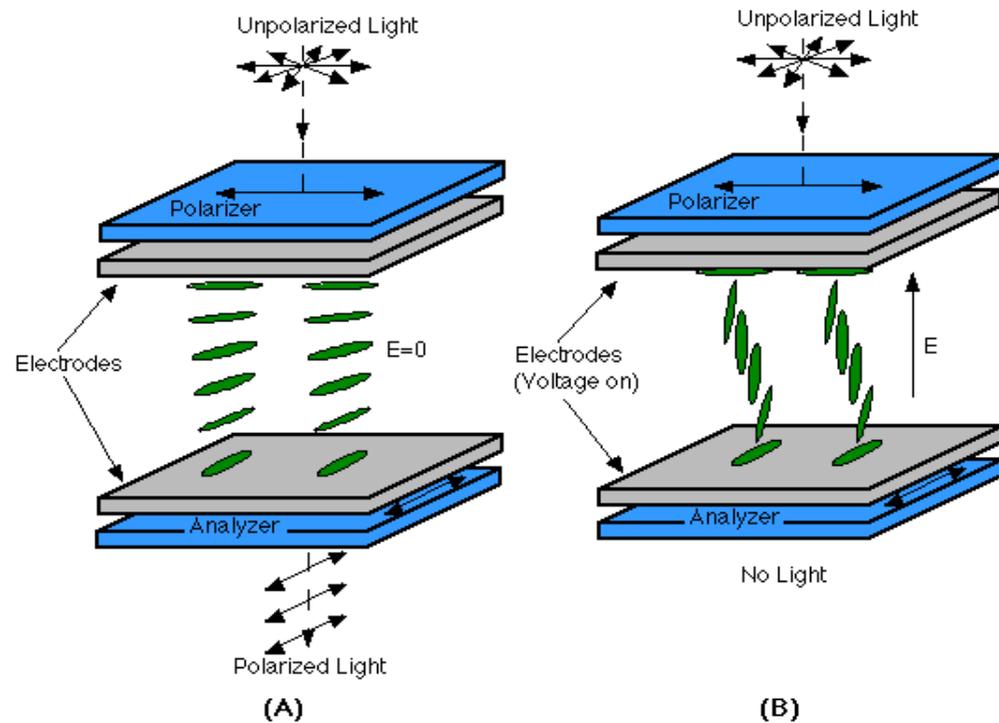
M.SC. IV SEMESTER
ELECTRONICS

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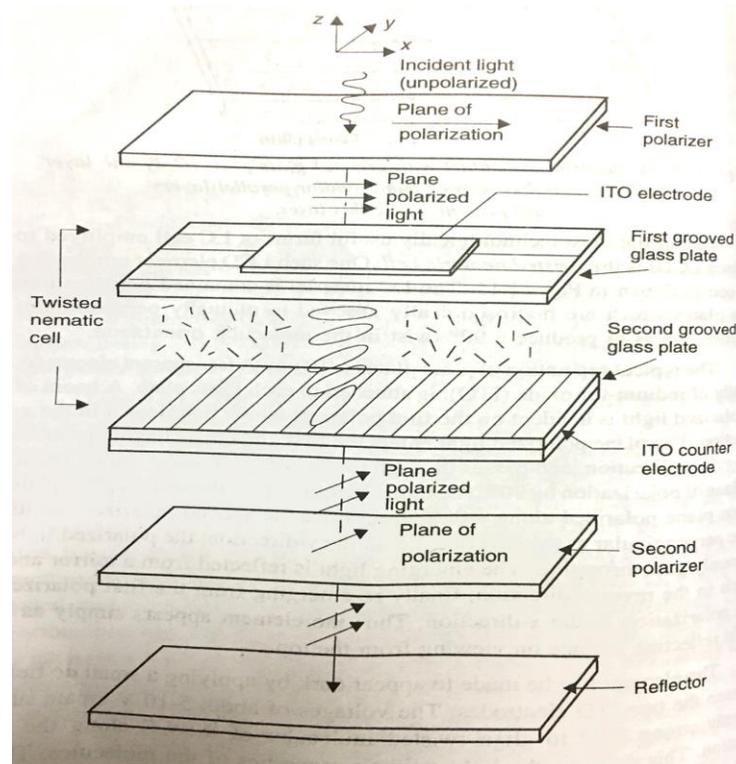
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LIQUID CRYSTAL

- These are the materials which exhibit properties of solids at low temperature and of liquids at high temperature. The molecules in solids are bound to orient along certain specific directions and occupy fixed positions with respect to each other. In liquids, molecules neither have directional nor positional constraints. In liquid crystals, an intermediate phase between the solid and the liquid exists- the molecules do not possess any positional order, but they exhibit some degree of directional order. They prefer a certain direction more than the other directions. This specific direction is called the **director** of the liquid crystal.
- Of the various existing sub groups of LCs, **Nematic** liquid crystal is most commonly used. The name comes from the Greek word for *thread* because of the thread like structure in the substance seen under the microscope. The nematic phase is the simplest form of liquid crystal in which the crystal molecules have no orderly position and can move in any direction. However, in this phase molecules tend to point in a specific direction.
- The nematic liquid crystal causes the direction of polarization of light wave to rotate by 90° as the plane polarized wave passes through it.
- Liquid crystals undergo certain changes in their characteristics when electric field is applied to them. The effect is to align the director of the liquid crystal along the direction of the field. When an external field is applied, it affects the orientation of the molecules resulting in reduction of shifting of the plane of polarization. At low values, this effect is nominal and disappears entirely at very high voltages.



- One of the most useful forms of LC cell in LCDs is the **twisted nematic cell**. In an LCD panel, the LC compound is contained between two glass plates that are grooved in mutually perpendicular directions. The typical separation between the glass plates is 10 micro meter. When the nematic liquid crystal compound is placed in contact with a glass plate with microscopically grooved surface, the molecules align themselves along the grooves as shown in Fig C.
- A transparent electrode, usually made of Indium tin oxide is attached to each plate.
- A polarizer is attached to the upper surface of the glass plate. A beam of unpolarized light falls on this polarizer which polarizes it in the x - direction.



(D)

- The plane polarized light enters the first glass plate having grooves in the x direction, and passes through the nematic molecules with orientation along x axis. The LC compound rotates the plane of polarization of the polarized light by 90° , resulting in a plane polarized light emerging from the LC compound, with polarization along y axis.
- Light beam with y direction polarization falls on the second polarizer, which has its plane perpendicular to the first polarizer, i.e. in the y- direction. Hence, the polarized light easily passes through it.
- The emerging light is reflected from a mirror and travels in the reverse direction, finally re-emerging from the first polarizer with polarization in the x direction (Fig D). Thus, the picture element appears as a bright reflecting point on viewing from the top.
- Now, a voltage of about 5-10 V is applied between the two electrodes. It creates sufficiently strong field to align nematic molecules of LC along the z direction. As mentioned earlier, the electric field destroys the light guiding properties of the LC molecules. The light entering the second polarizer is no longer plane polarized along y direction, but is scattered and can not fully pass through it. Thus a little light is reflected and the area covered by this specific element will appear dark.
- By selectively applying voltage of appropriate value at specific elements, patterns of dark and bright pixels appear on the screen of LCD.
- Colour LCDs display pictures in colour by using sub pixels with red, green and blue colour filters to create each colour pixel.

References and suggested readings:

1. Solid State Physics - Saxena, Gupta, Saxena
2. Solid State Physics and Electronics –Puri & Babbar