Liquid Crystals

Last updated 2/29/24

Liquid Crystals

- LCD vs LED Displays (TVs)
  - The vast majority of what are labeled LED displays are actually LCD (Liquid Crystal) displays
  - True LED displays are available – at a premium price (OLEDs)

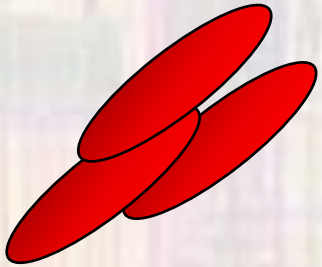
Liquid Crystals

- Liquid Crystal
  - Polymeric organic compounds
  - Two major molecular shapes
    - Rods – Calamitic
      - Major Axis – Director

    - Discs – Discotic

Liquid Crystals

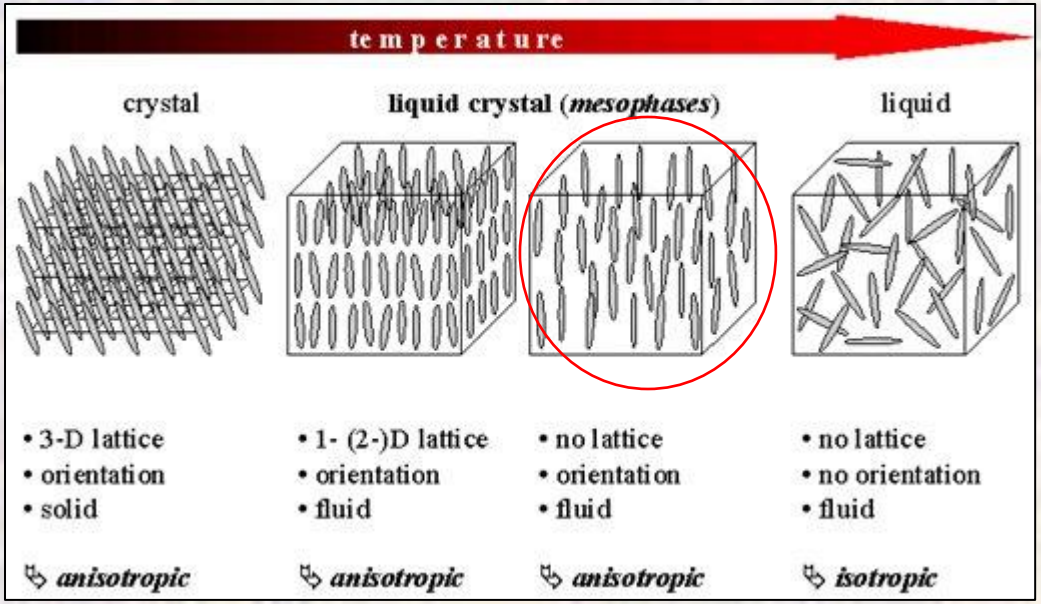
- Structure Types
  - Nematic – have orientation but no relative structure



  - Cholesteric (twisted nematic) – Helix structure

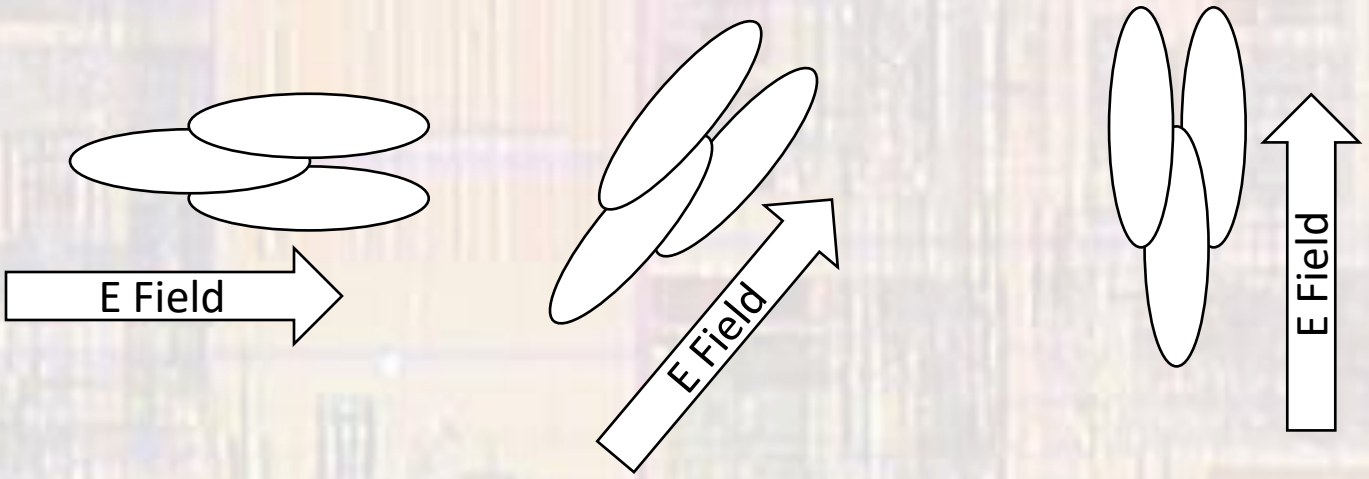
Liquid Crystals

- Crystal Lattice
  - Lattice changes with temperature



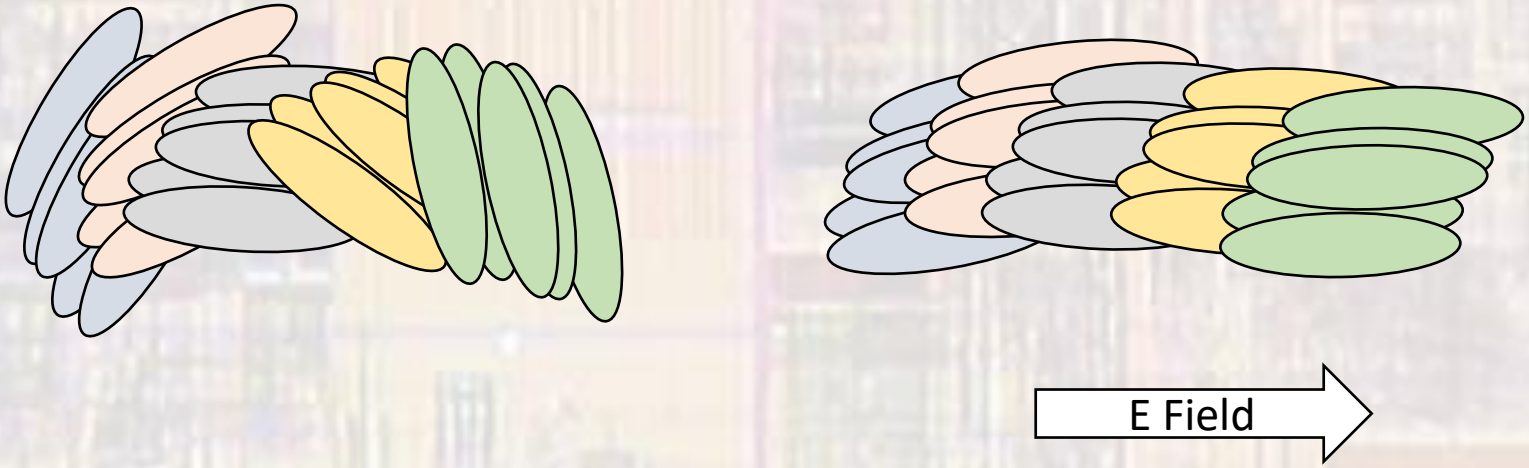
Liquid Crystals

- E-Field Effects
  - In an electric field
    - Nematic crystals align the director to the external E field



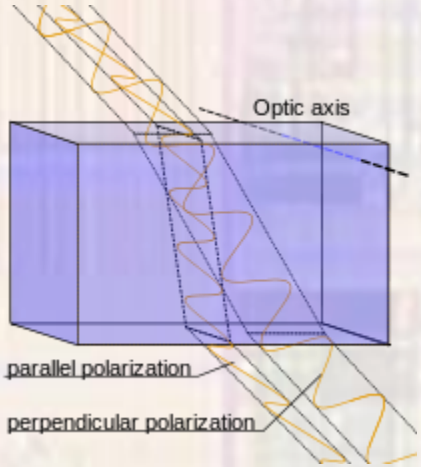
Liquid Crystals

- E-Field Effects
  - In an electric field
    - Cholesteric (twisted nematic) crystals align the director to the external E field



Liquid Crystals

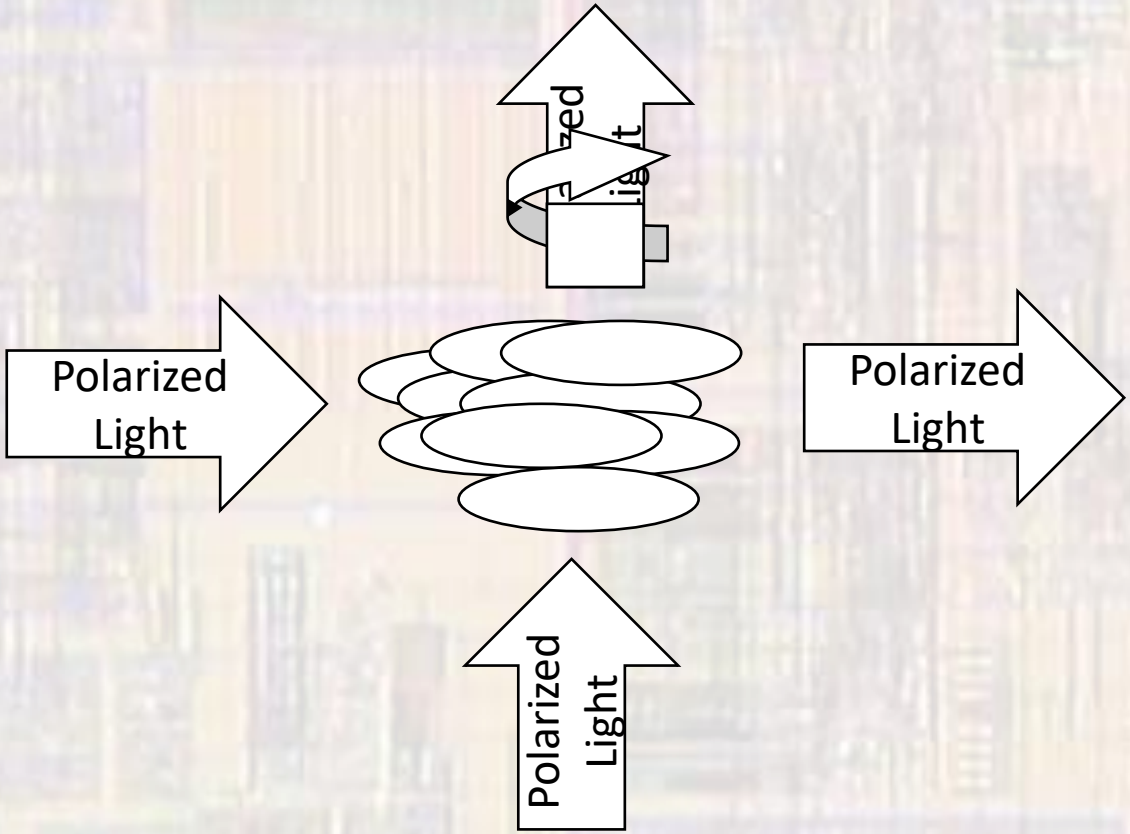
- Birefringence
  - Optical Property of a material
  - Index of refraction is dependent on the direction and polarization of incident light



src: Wikipedia

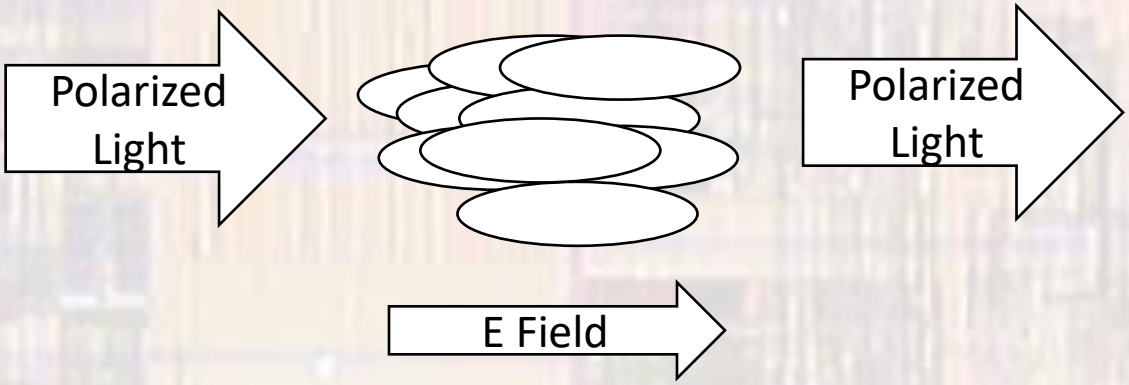
Liquid Crystals

- Liquid Crystal - Birefringence
  - Polarized light
    - Passes unchanged in the direction of the director
    - Rotates polarization in other directions



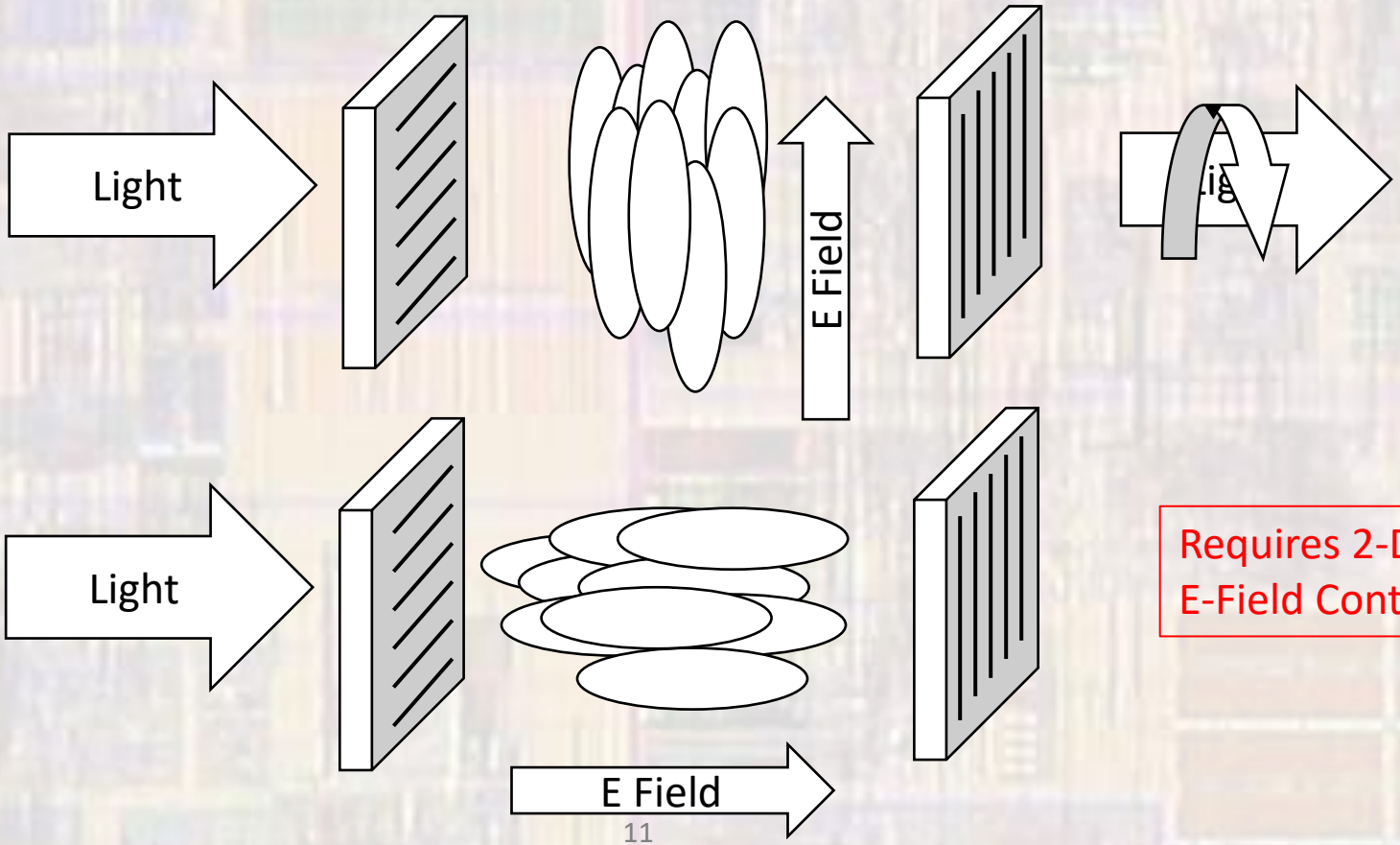
Liquid Crystals

- Put it all together
  - Use an electric field to align the crystals
  - Shine polarized light through it



Liquid Crystals

- Put it all together
  - Add some polarizers
    - Use an electric field to orient the crystals
    - Shine polarized light through it

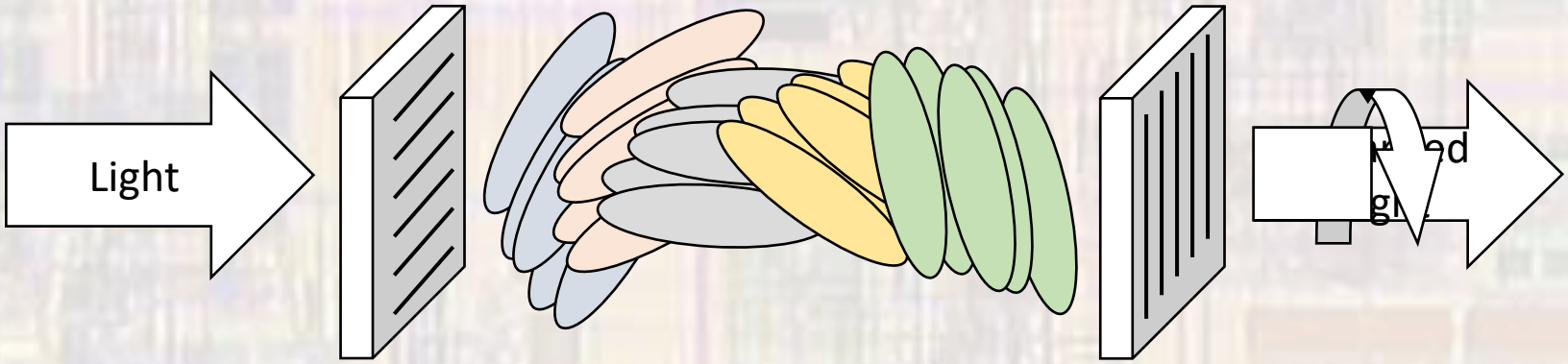


Liquid Crystals

- Use the twisted nematic structure
  - Birefringence of the LC causes the light to rotate
    - If polarizers are out of phase

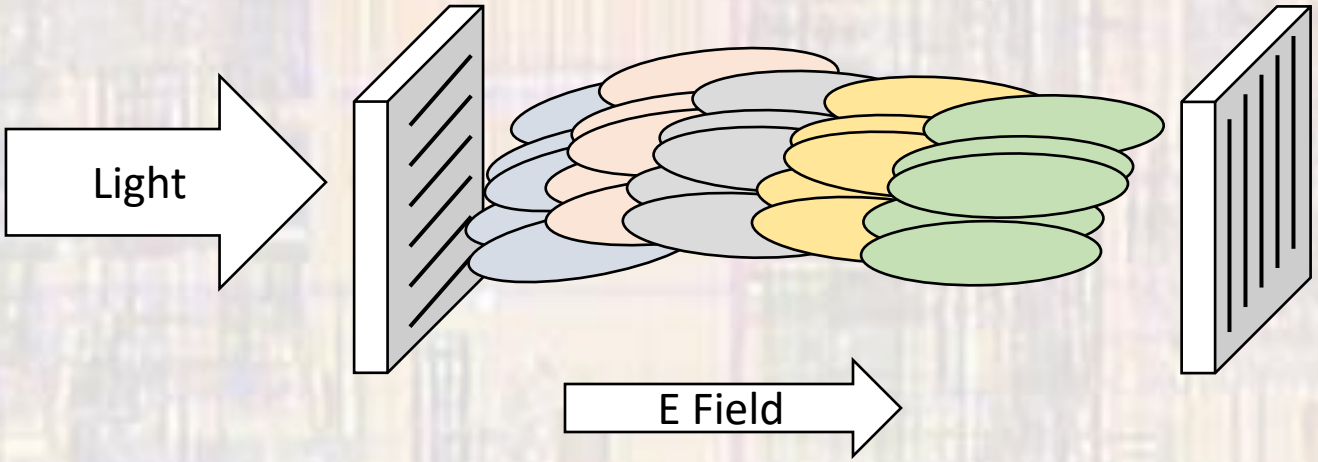
      And
    - the rotation matches

      → LIGHT PASSES



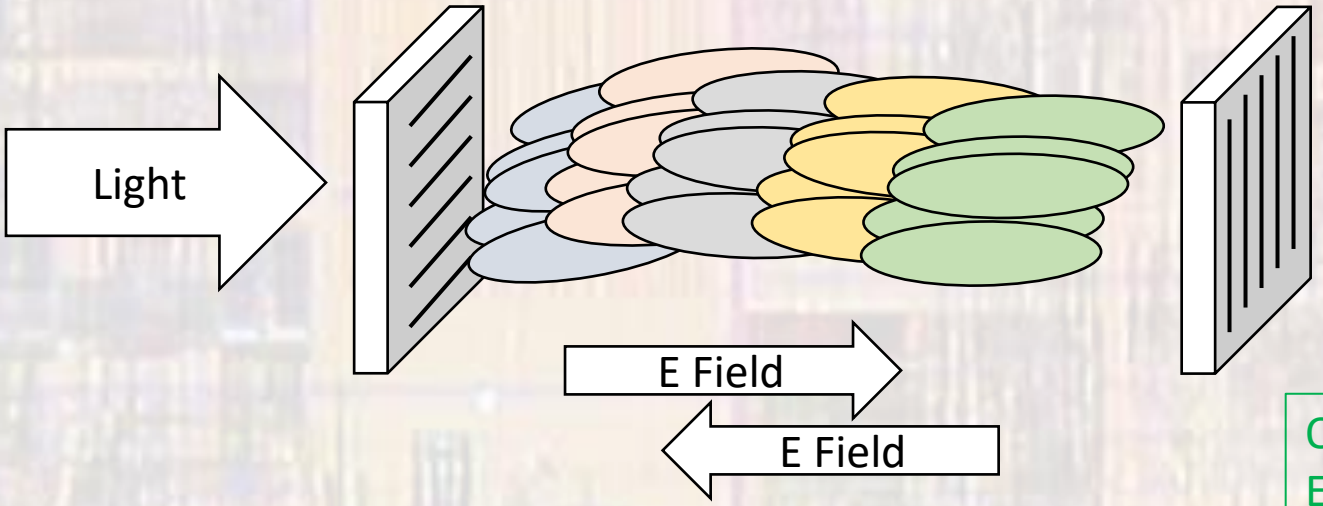
Liquid Crystals

- Use the twisted nematic structure
  - Now add an electric field
  - Directors align with the E field
  - Light is not rotated - NO LIGHT PASSES



Liquid Crystals

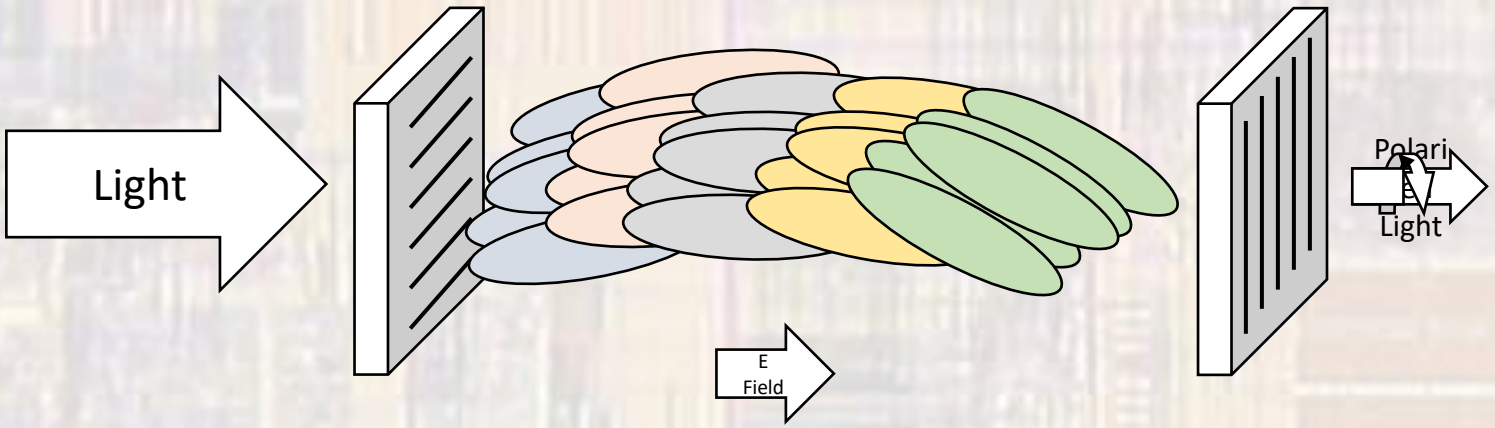
- Use the twisted nematic structure
  - Note – the absolute direction of the E field is not important



Only requires 1-D E-Field Control

Liquid Crystals

- Gray Scale Control
  - Amount of light that passes is dependent on the voltage
    - Gray scales
  - Normally white– Polarizers rotated, no field – light passes
  - Normally black – Polarizers aligned, no field – no light



Liquid Crystals

- Color
  - Add a color filter (R,G,B)