AMOLEDs

Active Matrix Organic Light Emitting Diode

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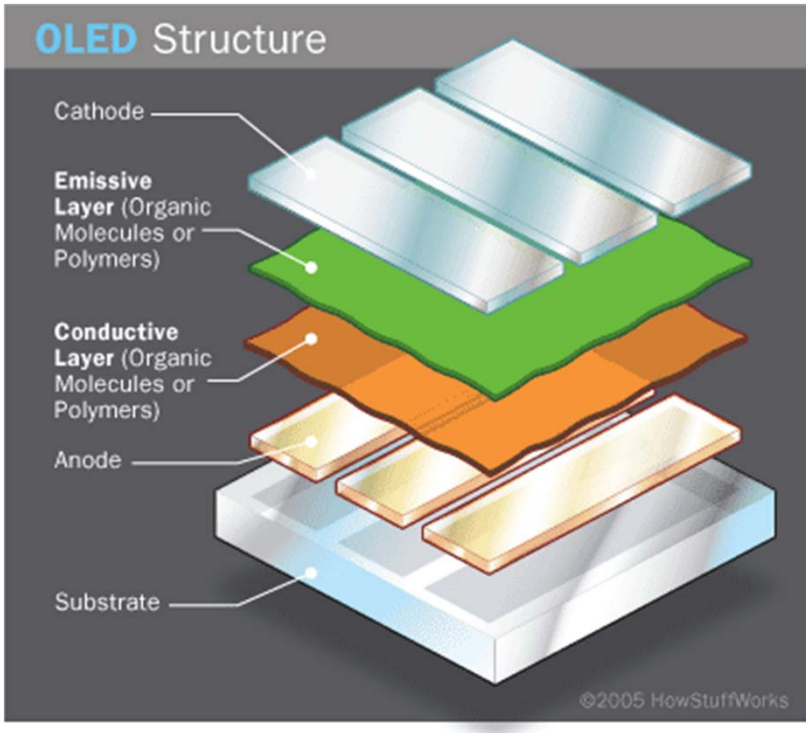
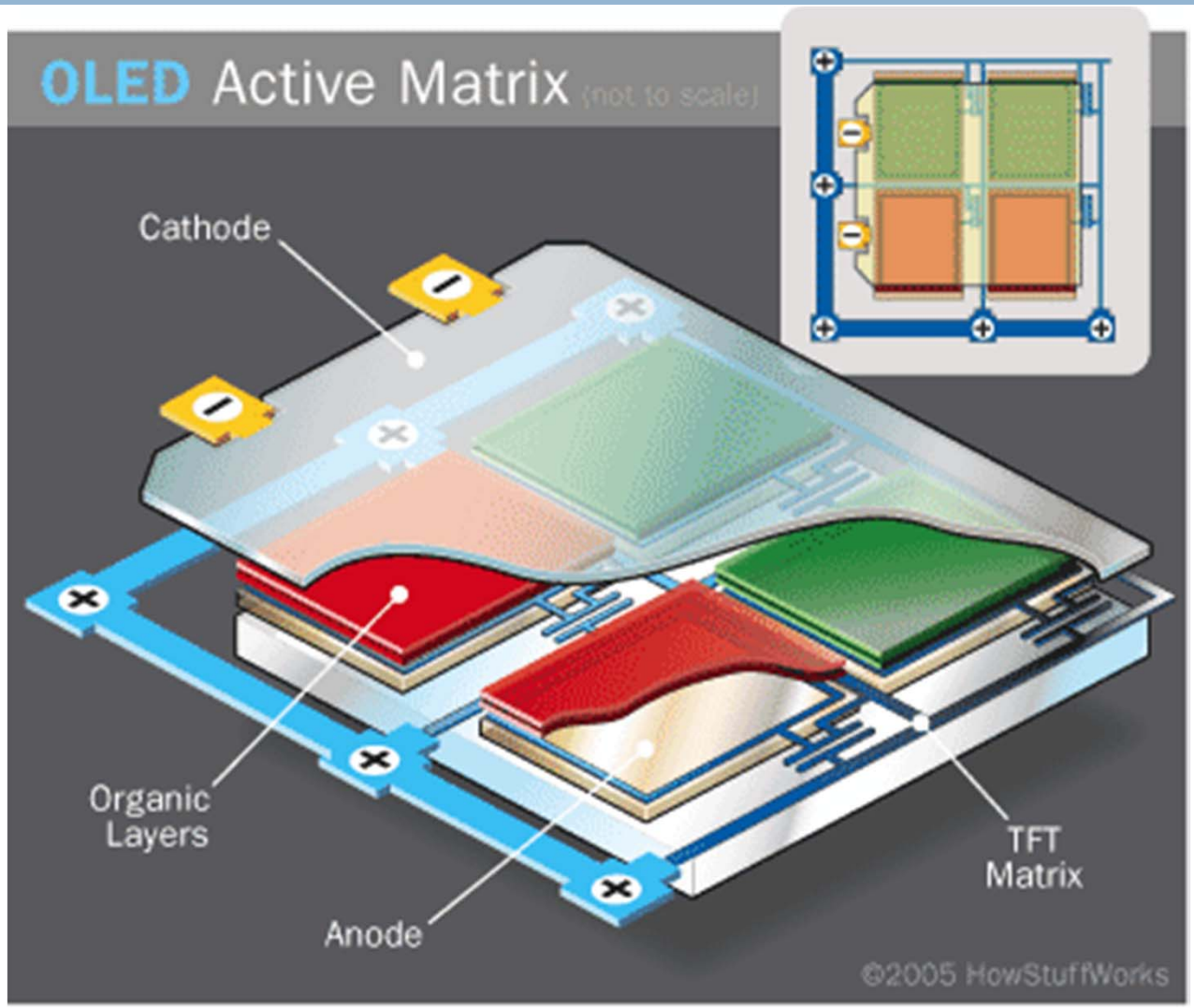
ECE 3080

OLED

- Organic LED
- The emissive electroluminescent layer is a film of organic compounds
- This layer of organic semiconductor material is situated between two electrodes
  - Generally transparent



AMOLED


OLED Active Matrix (not to scale)
Cathode
Organic Layers
Anode
TFT Matrix
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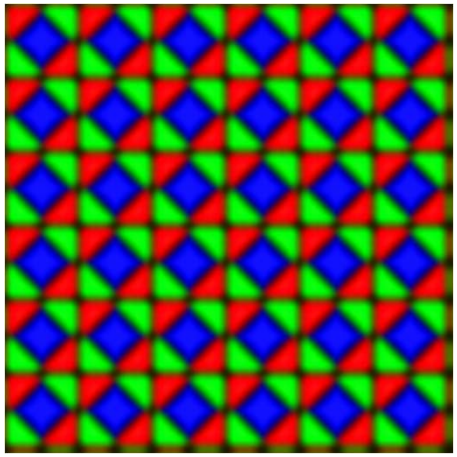
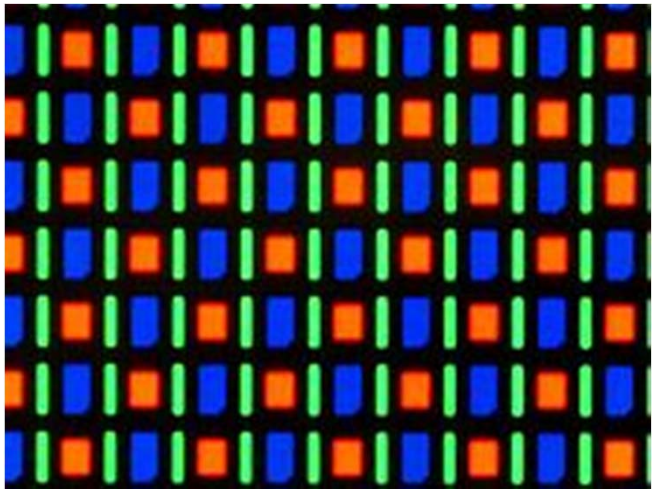
AMOLED

- Mainly used in mobile phones and TVs
- Lower-power, lower-cost, larger-size available
- Displays implement a system of the PenTile matrix family sub-pixel matrix schema



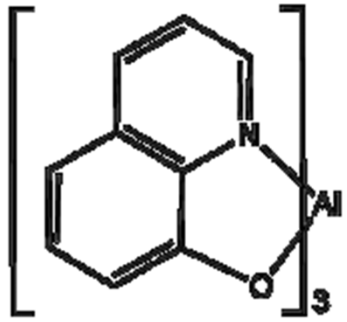
RG-B-GR



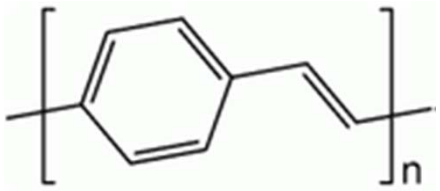
RGBG

Materials for Semiconductor

- Small molecules
  - Commonly organometallic chelates (i.e. Alq_3)
    - Organic molecules that trap highly reactive trace metal cat-ions
    - Bonding the metal ion to an organic molecule

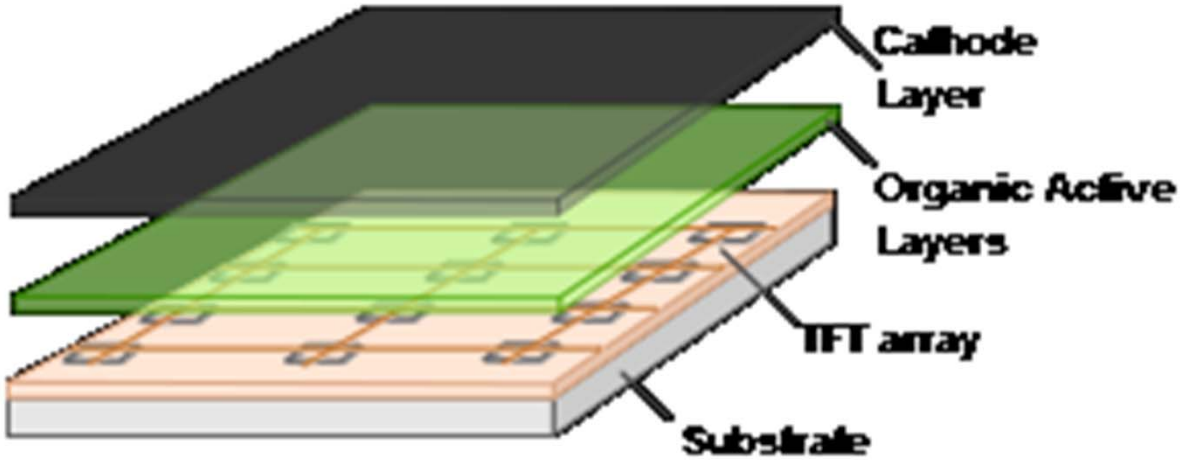


- Polymers
  - Electroluminescent conductive polymer that emits light when connected to an external voltage
  - Used as a thin film for full-spectrum color displays
  - poly(p-phenylene vinylene)
    - highly ordered crystalline thin film
  - **Changing the side chains changes the color**



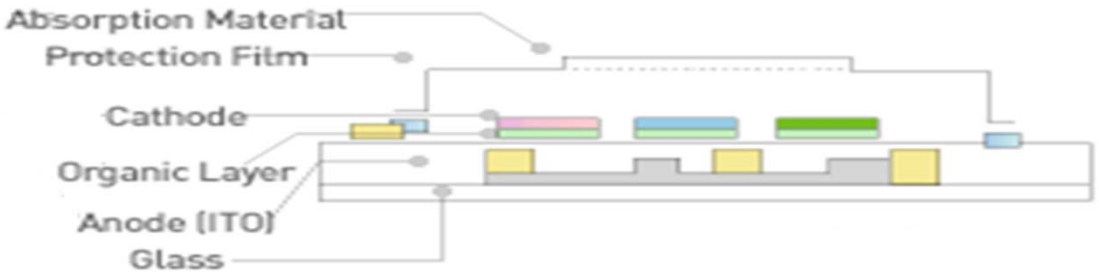
TFT (thin-film-transistor)

- The matrix of OLED pixels generate light from an applied voltage to a TFT array
- This current flow is controlled by two TFTs at each pixel
  - To start and stop the charging of a storage capacitor
  - To provide a voltage source to create a constant current to the pixel
- Mainly used are:
  - Poly-Si
  - a-Si



AMOLED Fabrication

- Si is being replaced with amorphous InGaZnO (a-IGZO).
- steps:

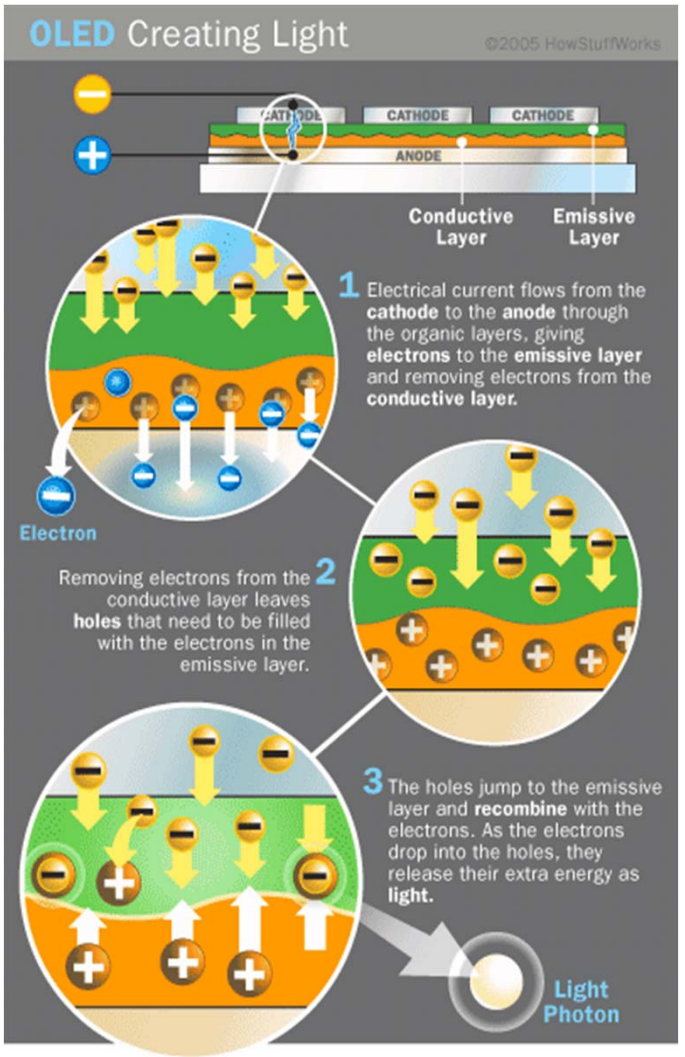


1. Make backpane of TFT
2. Cleaning of substrate
3. Doped Si precursor and SiO_2 insulating layers are added to substrate via (PECVD)
4. Photolithography and etching (with two transistors per pixel)
5. Indium-tin-oxide (InSnO) (which is transparent) is spin coated on backplane
6. Light emitting polymers (organic part) (either spin coating or printing)
7. Cathode – usually thin layer of calcium and aluminum to enhance conductivity

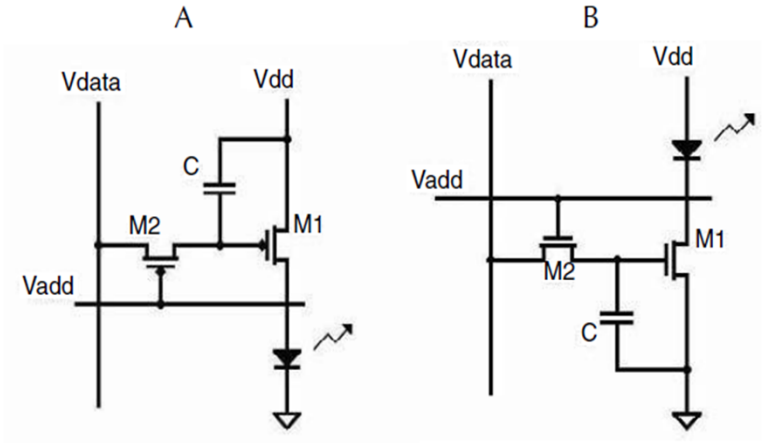
How do they work?

- The TFT array determines which pixel gets turned on
- Electric current flows from the cathode to anode through organic layer
  - cathode gives electrons to emissive layer
  - Anode removes electrons (creating holes in conductive layer)
- Holes and electrons recombine and give off light
- Light color depends on type of organic

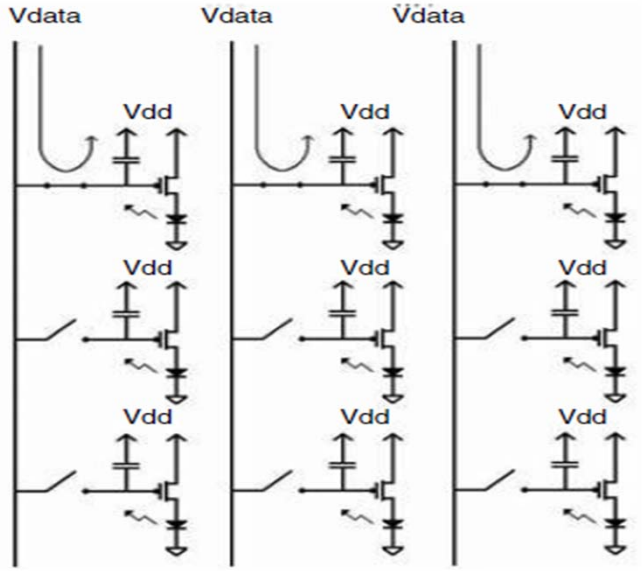
  Material in the emissive layer



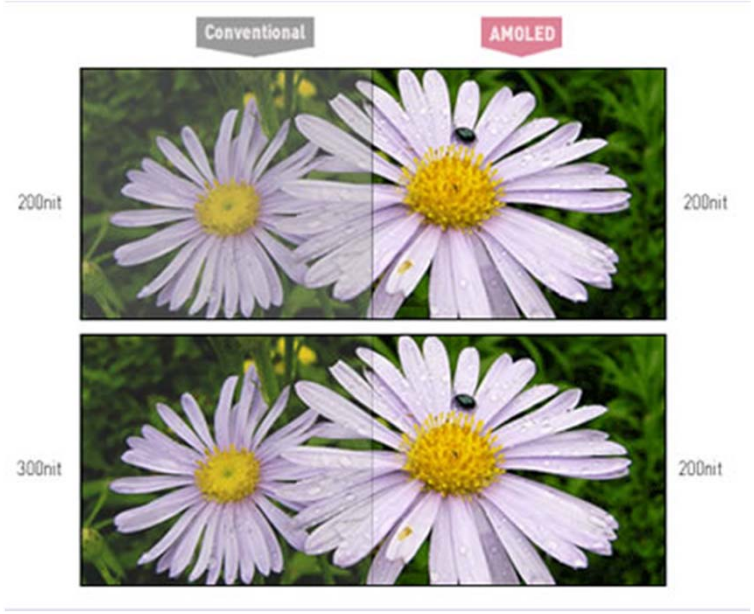
Circuitry

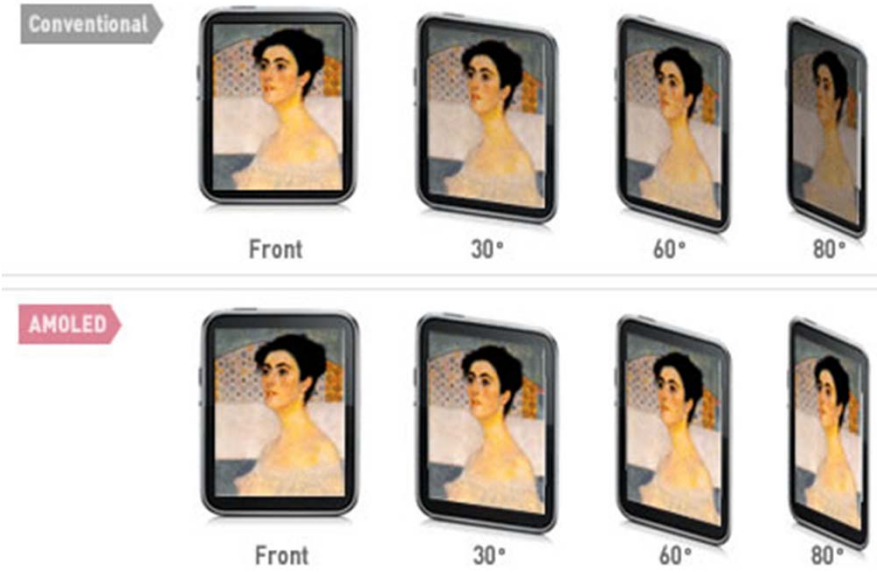


- P-MOS implementation (A)
- N-MOS implementation (B)
  1. P-MOS more common: voltage changes across the diode (Vadd) do not affect the current output.
  2. (this current is controlled by the TFT gate-source voltage: *V*data – *V*dd).
  3. Vdata controls brightness
  4. Vadd is a select, which enables Vgs on M1 and turns on current across diode emitting light



Comparison with Conventional LCD-TFT Screens





Advantages/Disadvantages

Advantages

- Excellent brightness
- Great color and contrast potential
- Relatively inexpensive to manufacture
- Thin, lightweight & durable
- Fast response time
- physically flexible and rollable (LEPs)

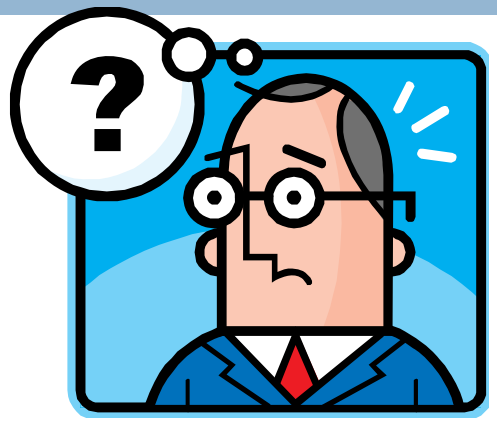
Disadvantages

- Difficult to view in direct sunlight
- Supply shortages due to high demand
- Short life expectancy (especially blue)
- Differing life expectancies for each color resulting for potential of color shift over time
- Currently prototype-only for larger screen sizes - most OLED displays are for portable devices

Whats Next?

- Super-AMOLED
  - Touch detection layer integrated into screen
- Super-AMOLED-Plus
  - Instead of PenTile RGBG / RG-B-GR, sub-pixel arrangement in simple RGB = finer detail

Questions and Discussion



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