ECE 5320
Lecture #17
Electroluminescence

- LCD (liquid crystal device)
- OLED (organic light-emitting diode)
- Nanoparticle-based electroluminescent device

- longer life
- cost
- manufacturability
- control
Electroluminescence

Figure 6.47 The basic principle of electroluminescence. Electrical energy is transformed into light; in an electroluminescence device, this is caused by the excitation of nanoparticles with electrical energy.

Electric field $E$

$\text{hole}$

$\nu$ - photon
Device

Figure 6.48 The set-up of an electroluminescence device. This normally consists of a glass carrier plate coated with an optically transparent electric conductor (ITO). The next layer contains the electroluminescent particles, which is coated with an aluminum counterelectrode.

- ITO (Indium Thin Oxide) - conductive but transparent electrode
- NP - Electroluminescent
Device

ITO $\oplus$ injection to NP

Work Function ($E_W$, $E_{F,\text{ Fermi}}$)

Conduction $E_F$

$V_{\text{Valexc}}$

Valence $V_{\text{Valexc}}$

Semiconductor $N$

$N$-type (p, n, n'+p') low $E_W$, $E_F$
Device Scheme.
If we control size of np, we can control color (A)

\[ \frac{16}{(2n+1)^2} \]
Device

Polymer

- improving efficiency
  (polymer layer is multi-layer)

ITO hole injection

Emissive layer

might also luminesce
Example:

**Figure 6.50** Electroluminescence spectra of a CdSe/PPV multilayer system, consisting of 20 double layers, for different voltages. The emitted intensity increases with increasing voltage; the spectral distribution, however, remains unchanged [36].

**Figure 6.51** Electroluminescence intensity at the maximum of a CdSe/PPV multilayer system, consisting of 20 double layers, as a function of the applied voltage. A threshold voltage in the range of 2.5 V is clearly visible [36].
Example

**Growth Efficiency**

**Figure 6.52** Electroluminescence intensity at the maximum of a CdSe/PPV multilayer system, consisting of 20 double layers, plotted versus current density. The experimental values show only small deviations from a strictly linear relationship [36].

**Figure 6.53** Comparison of the photoluminescence intensity of ZnS nanorods and nanoparticles. Both types of material were doped with Cu and Al. Note the significantly higher intensity obtained with nanorods. The wavelength shift of the maximum is caused by different sizes of particles and rods [38].

\[ \text{Size} \quad \text{vs} \quad 0 \]
Example:

Figure 6.54: Electroluminescence spectra of doped ZnS nanorods and nanoparticles. Both types of material were doped with Cu and Al. As shown in Figure 6.53, a significantly higher intensity is obtained with nanorods. The shift of the maximum is caused by different sizes of particles and rods. Compared to photoluminescence, the emission maximum of the rods shows a 5-nm red shift [38].

Figure 6.55: Electroluminescence intensity of doped ZnS nanorods and nanoparticles. Note that the improved performance of the rods starts at about 30V [38].

Size dependency benefit is also voltage dependent.
Example:

Very much growing much.