

Manufacturability of OLED Encapsulation and Light Extraction

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DOE-SSL OLED Stakeholders Meeting

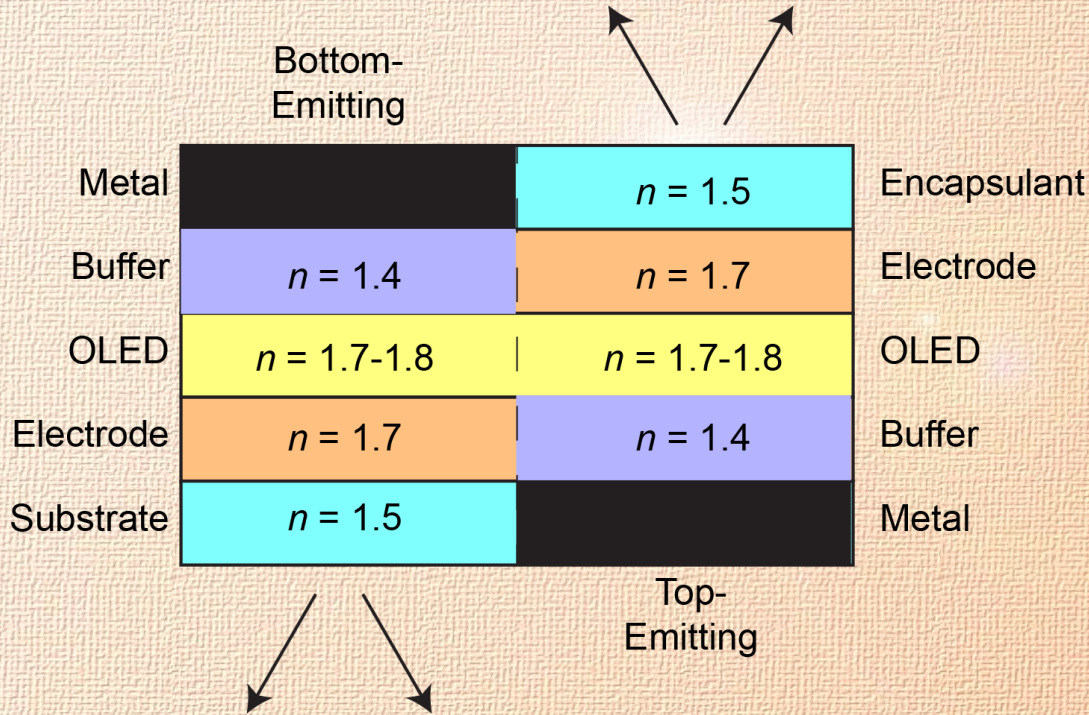
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OLEDs Require Encapsulation and Help Extracting Light

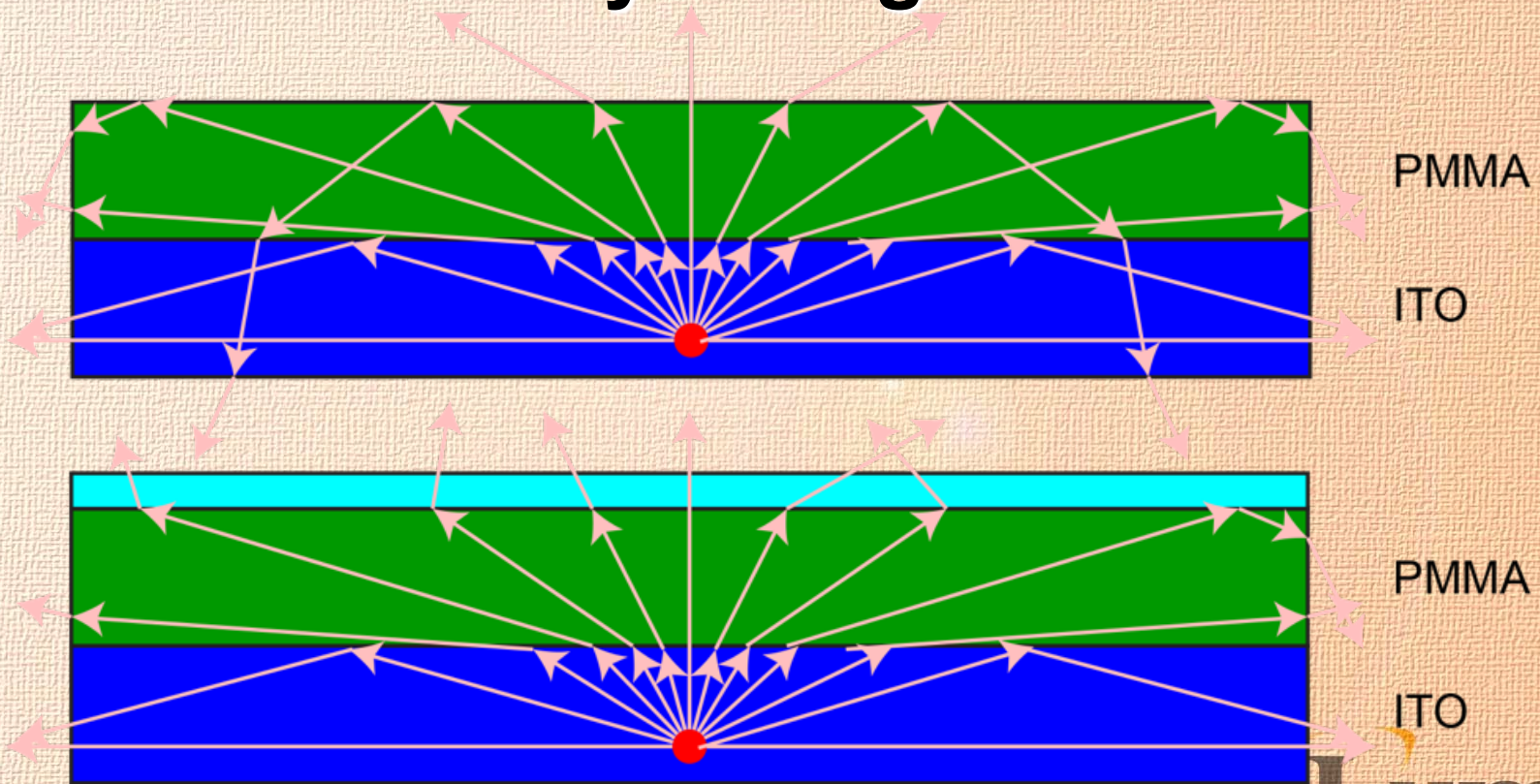
- Encapsulation for Protection
 - Oxygen resistance
 - Humidity, water, water vapor protection
 - Encapsulant must not affect OLED, ITO, or other coatings
- Encapsulant or Substrate can Help Extract Light
 - OLED and ITO typically have refractive index near 1.7
 - Encapsulants and substrates typically have refractive index near 1.5
 - TIR leads to waveguided modes, causing losses

OLEDs – Extra-Simplified Model

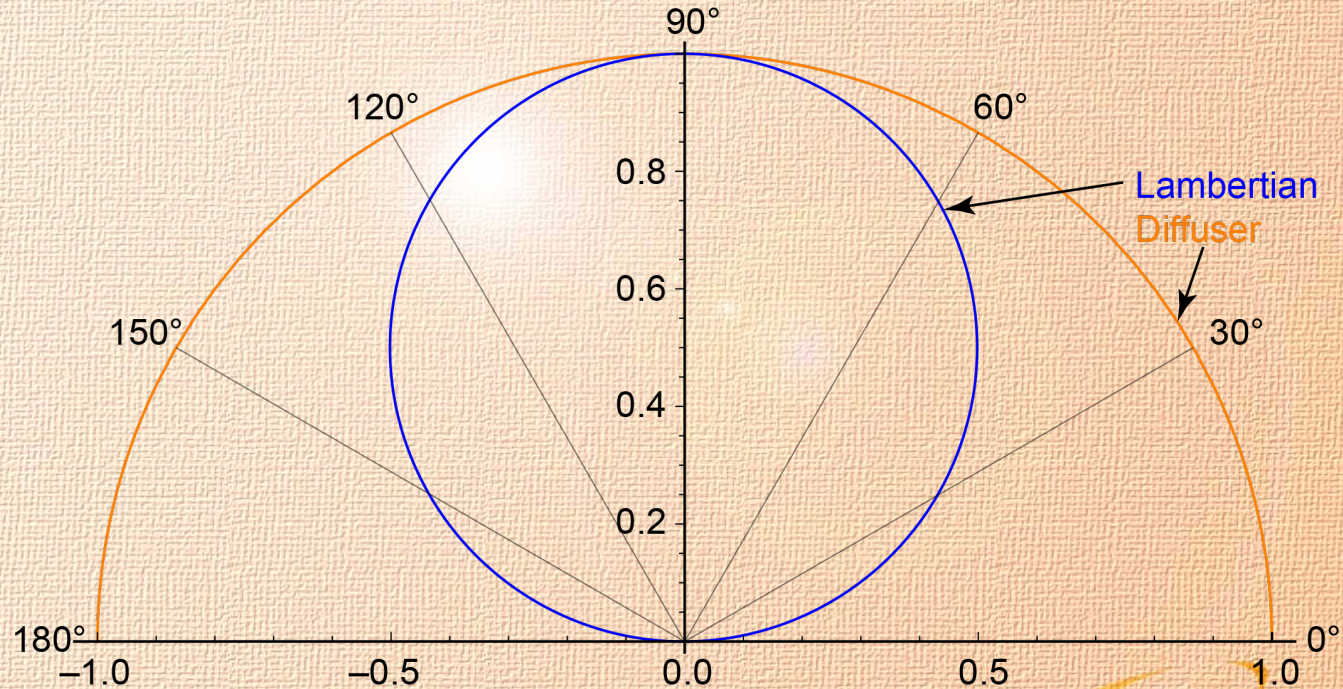


- Top-Emitting Almost Like Bottom-Emitting
- Metal Electrode is Also Reflector

Raytracing Model

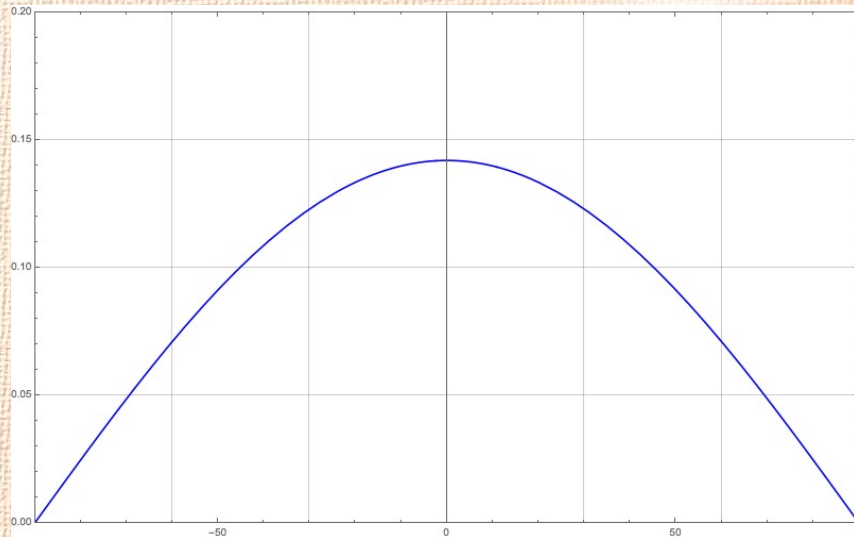


Theoretical Improvement with Pattern

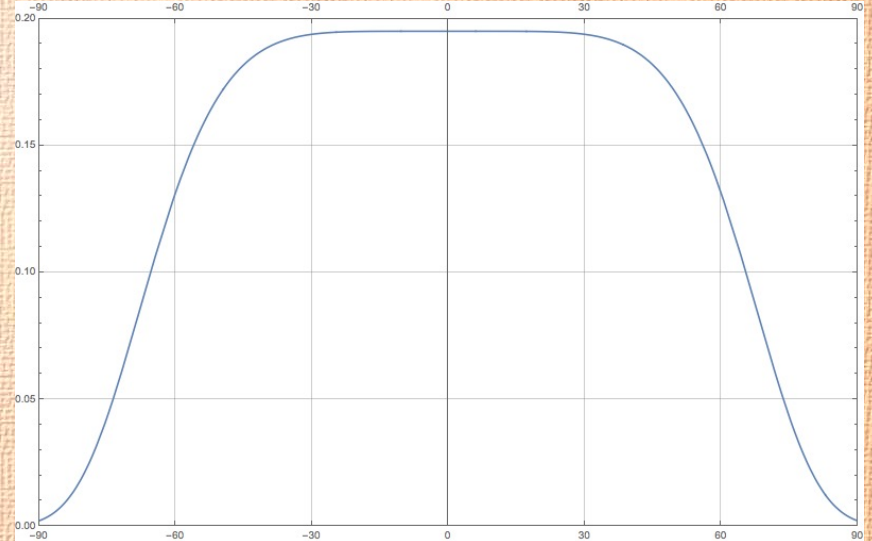


Raytrace Model: Cross-Section

Smooth PMMA Output

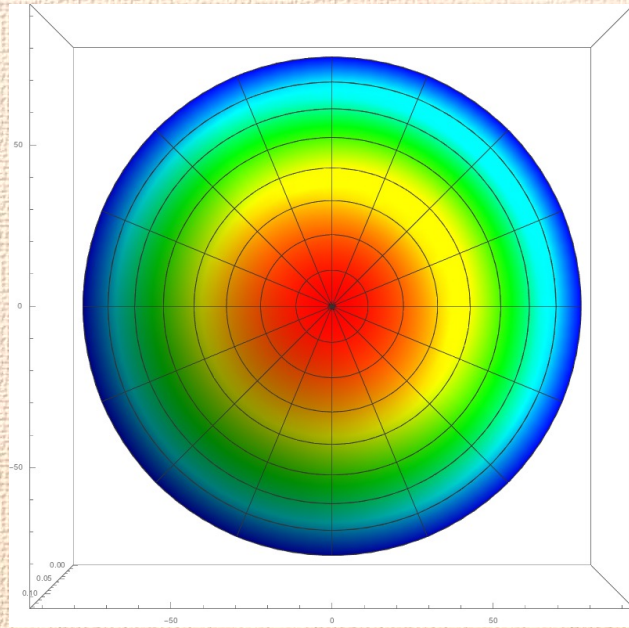


Patterned, 50% Higher Peak

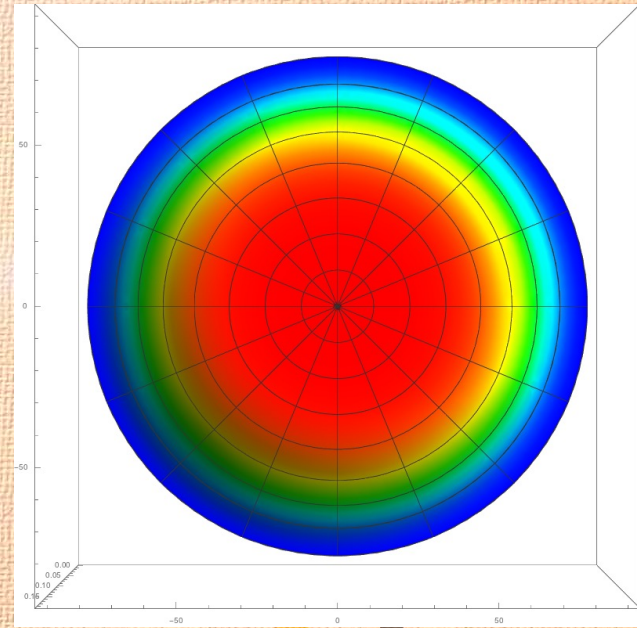


Raytrace Model: Illumination

Smooth Surface



Patterned: >Twice Total



How to Improve OLEDs Optically?

- Find single-layer encapsulant
 - Multiple layers can lead to loss in top-emitting OLEDs
 - Multiple materials are more expensive and harder to manufacture
- Make encapsulant (Top) or substrate (Bottom) have $n = 1.7$
 - Matching ITO will prevent some waveguide modes
 - Patterning surface will improve light extraction
- Develop manufacturable methods for OLED assembly
 - Roll-to-roll processing
 - Automated encapsulation

Manufacturable Methods

- To make OLEDs manufacturable we need to leverage technologies from other areas
 - LEDs and other lighting technologies
 - Displays and similar assembly methods
- Ideal solution: encapsulant or substrate that has $n=1.7$, is flexible, is not brittle, seals against all hazards, does not affect OLED material or operation
 - Maybe someday...