Getting All the Light Out: Light Extraction from Organic Light Emitting Devices

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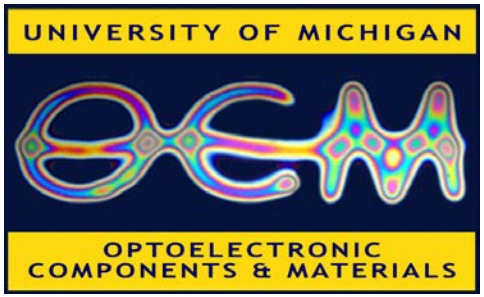
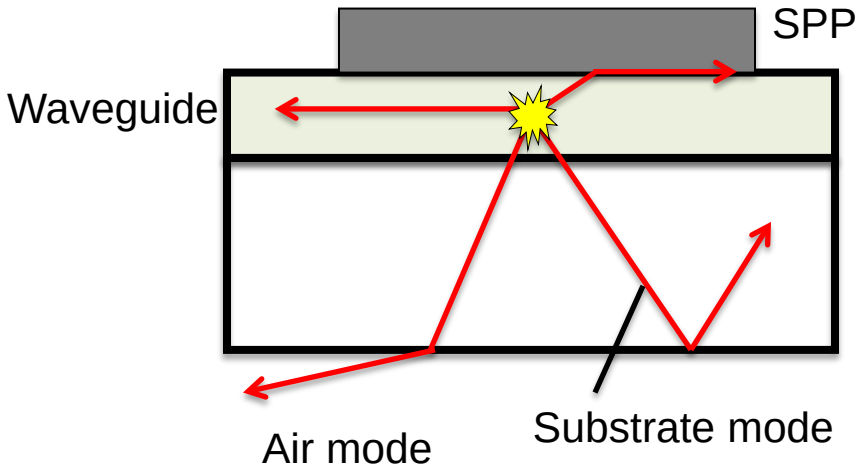


Motivation & Background

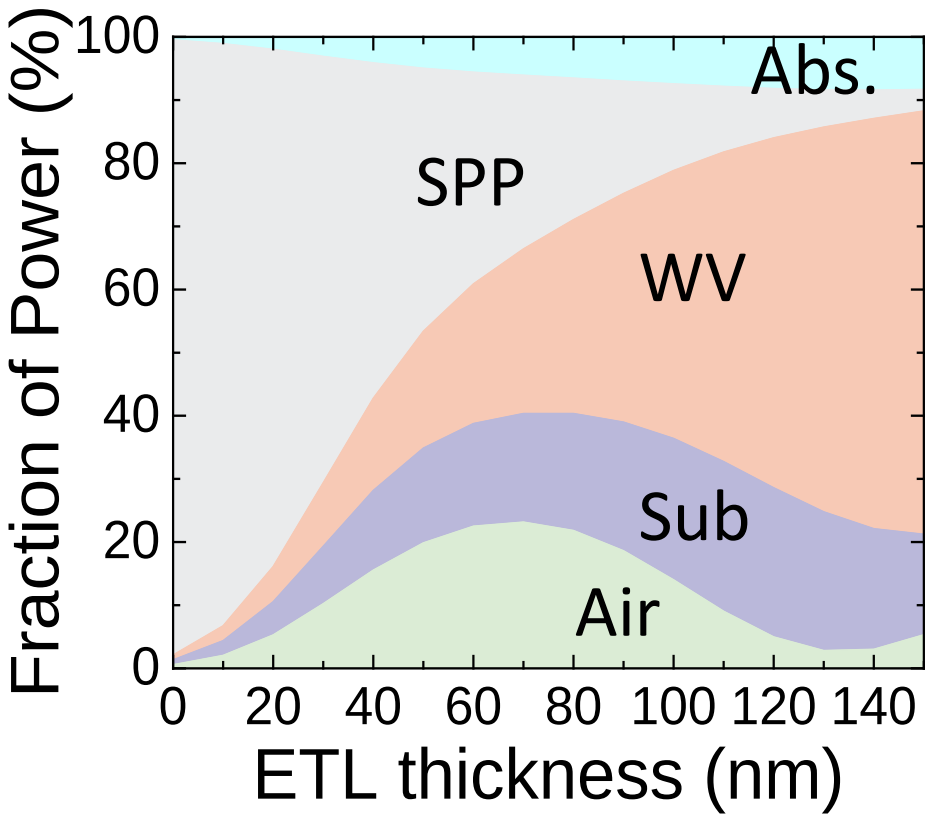
$$\eta_{EQE} = \eta_{IQE}\ (\sim 100\%^{1}) \times \eta_{Ext} \approx 20\%$$

- substrate modes
- waveguide modes
- surface plasmon modes



[1]Adachi et al, *J. Appl. Phys*. 90, 5048–5051 (2001)

Motivation & Background

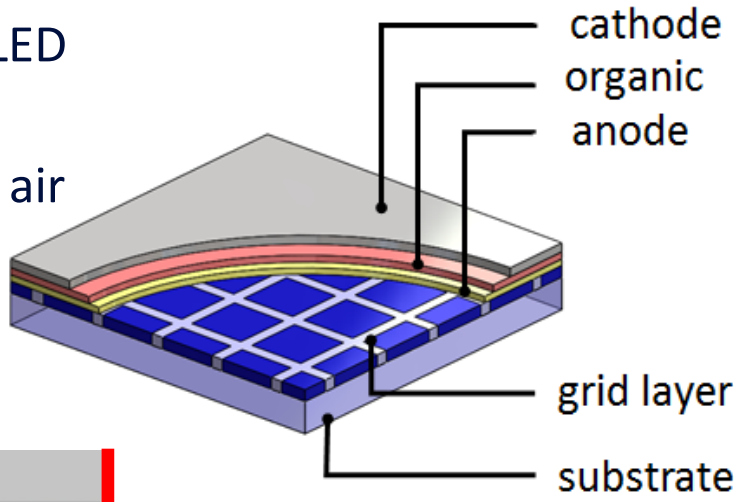


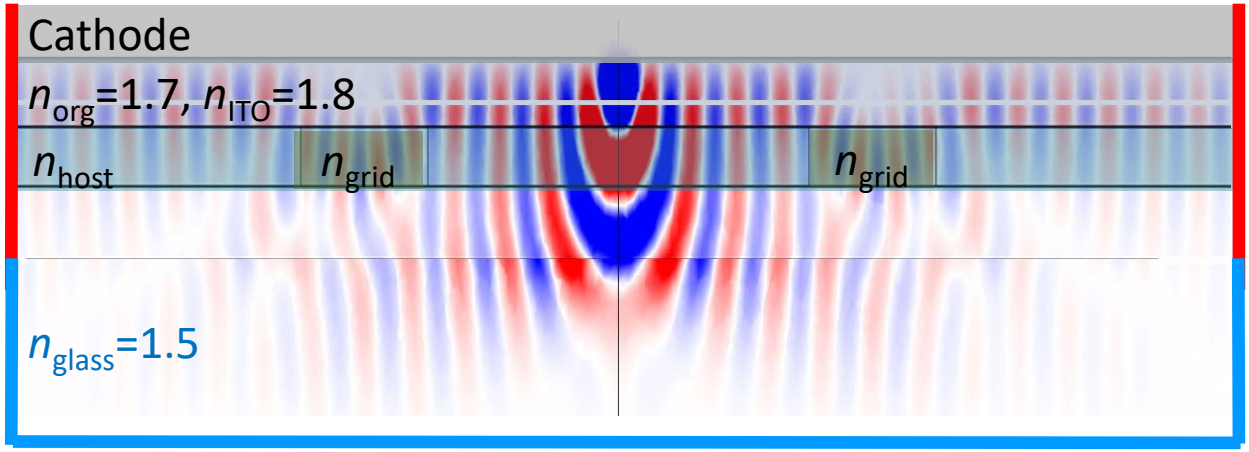
As ETL increases

- ❑ SPPs decrease
- ❑ Waveguide modes increase
- ❑ Substrate and air modes fluctuate

Sub-Anode Grid

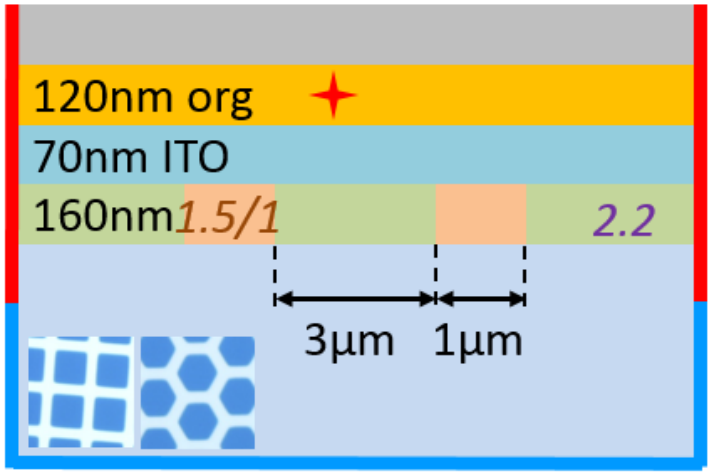
- A multi-wavelength scale dielectric grid between glass and transparent anode (sub-anode grid)
- The grid layer is planar and non-intrusive into OLED active region
- Waveguided light is scattered into substrate and air modes



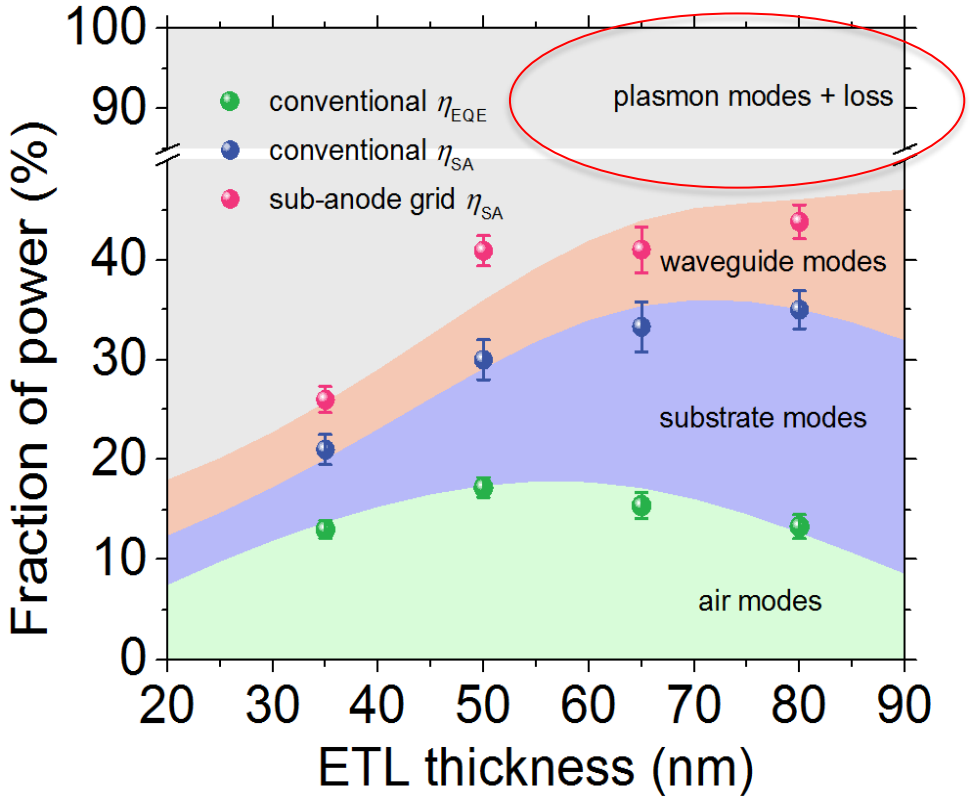


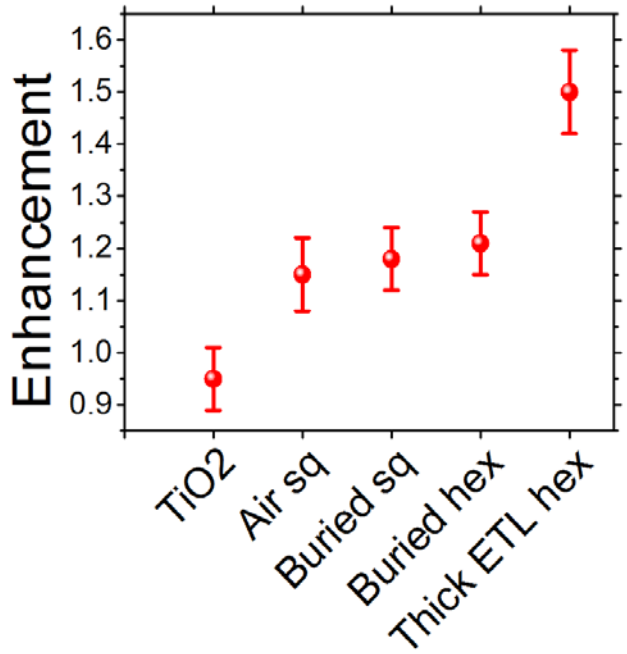
Qu, Slootsky, Forrest, *Nature Photonics* (2016)

Sub-Anode Grid



160nm grid/ 70nm ITO/ 2nm MoO_3/40nm CBP/15nm CBP:$Ir(ppy)_3$/xnm TPBi/1nm LiF/Al

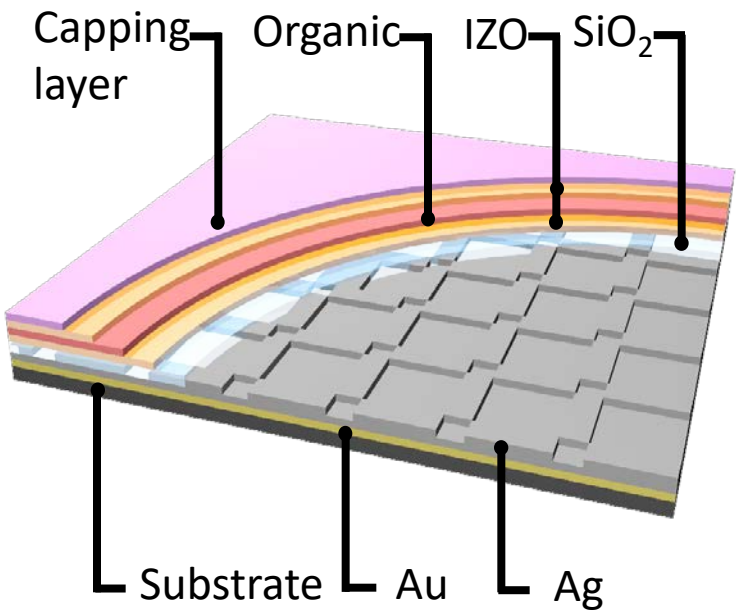




Thick-ETL organic structure:

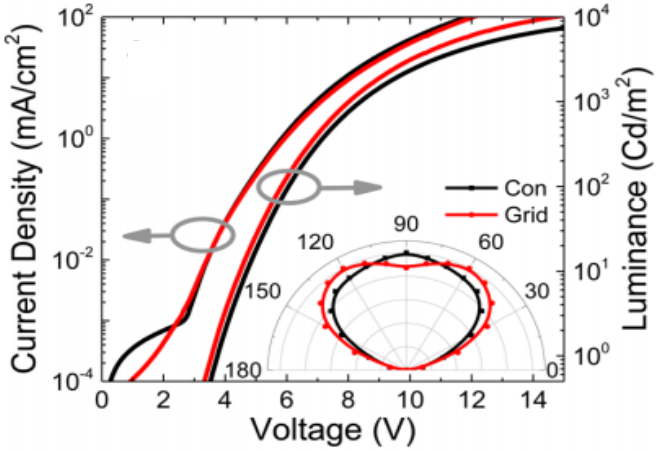
340nm grid/70nm ITO/2nm MoO_3/40nm TcTa/15nm CBP: $Ir(ppy)_3$/10nm TPBi/230nm Bphen:Li/Al

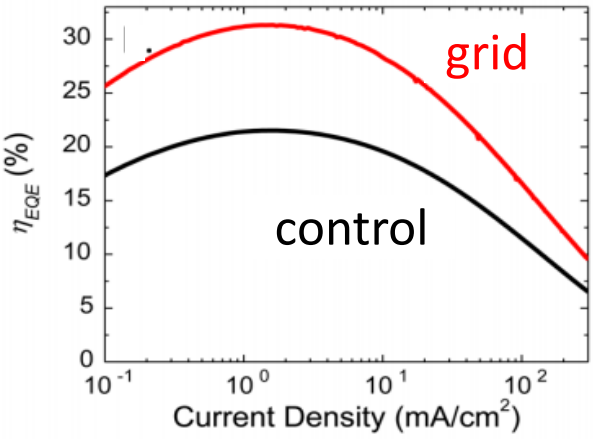
Sub-Electrode Grid in TE-OLEDs

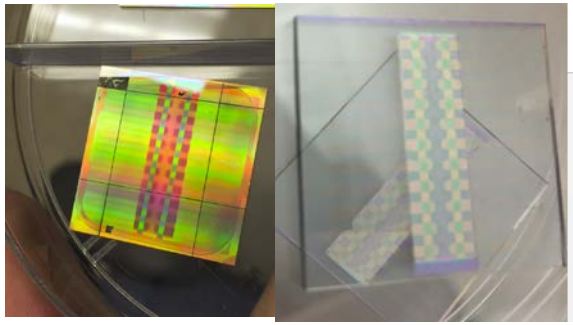


- Metal reflector far away from the EML
  No excitation of SPPs
- Grid >> optical wavelengths
- The grid is planar and non-intrusive into the active region

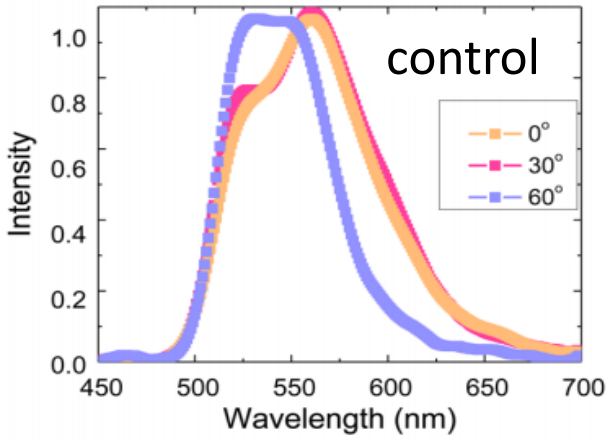
Sub-Electrode Grid in TE-OLEDs

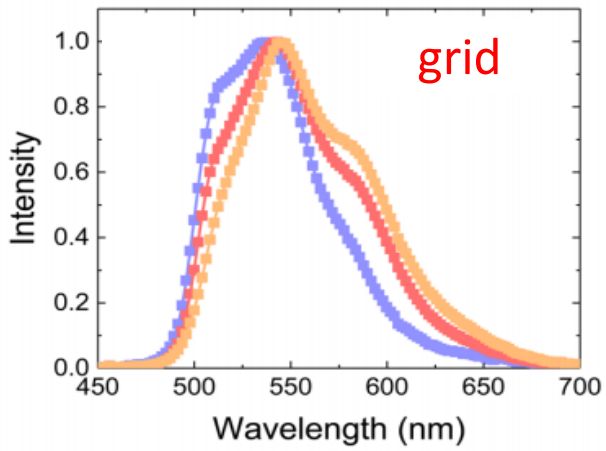


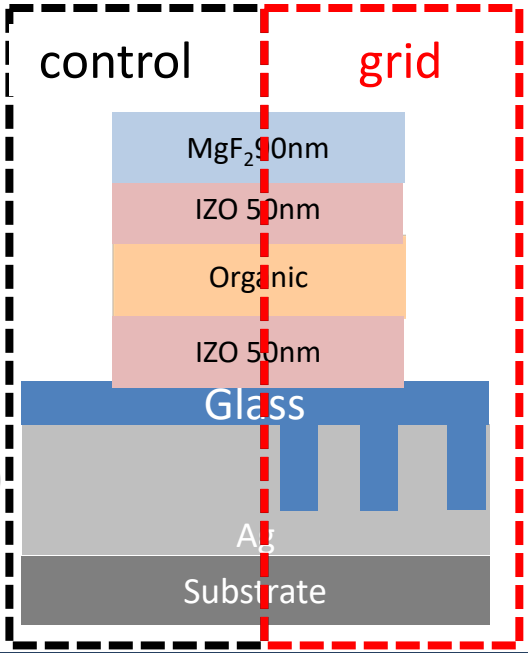




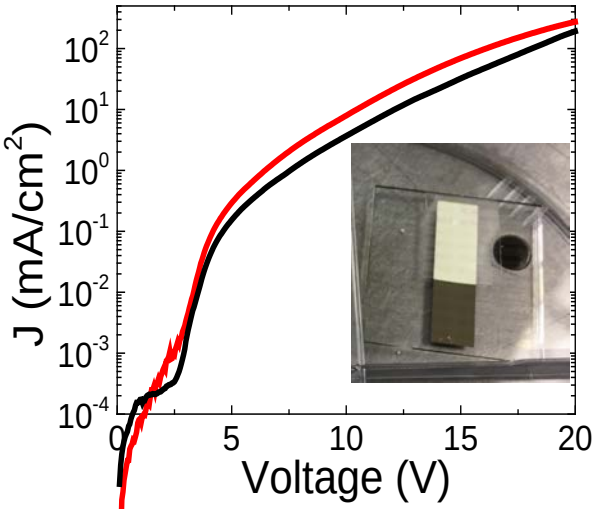
Organic structure: MoO_3 30nm/ BPhen: Li 30nm/ Bphen 30nm / CBP : $Ir(ppy)_3$ 25nm/ TAPC 40nm /MoO_3 30nm/

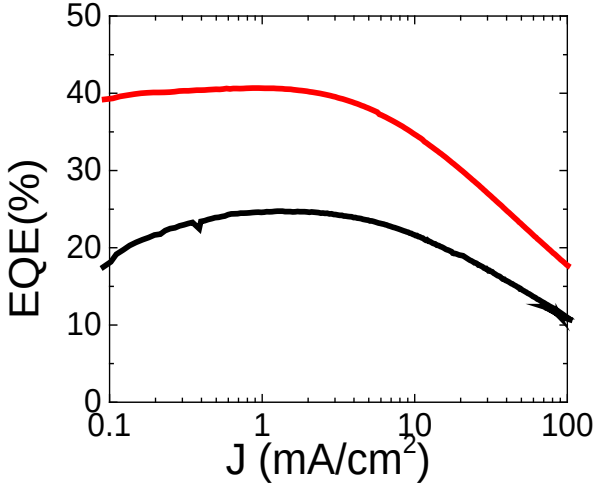




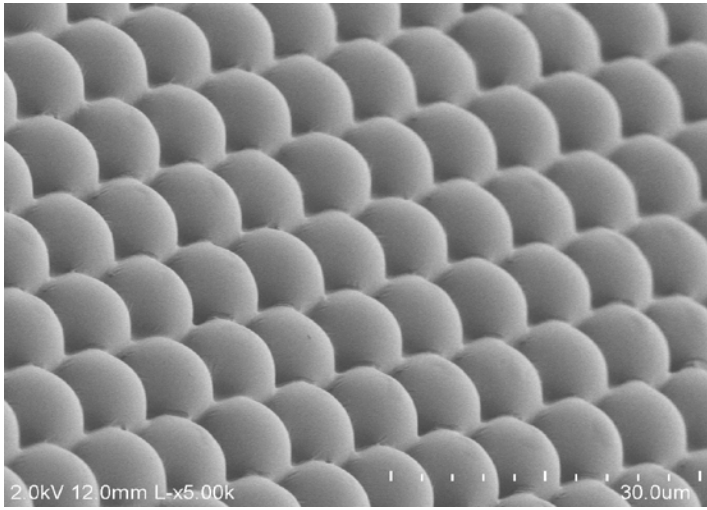


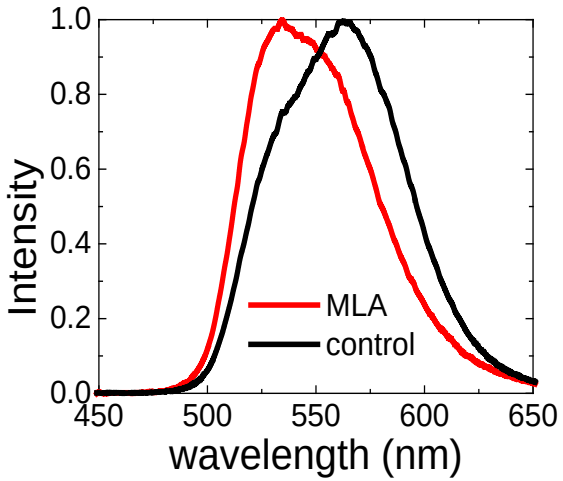
Microlens on Top of TEOLEDs

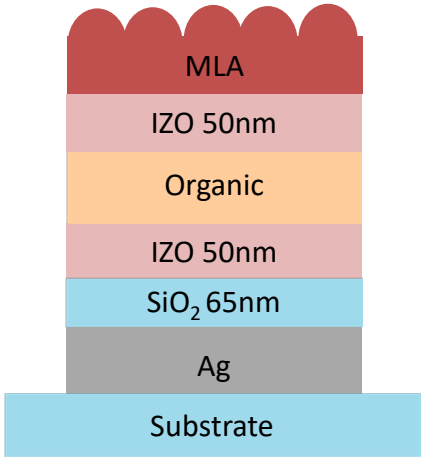




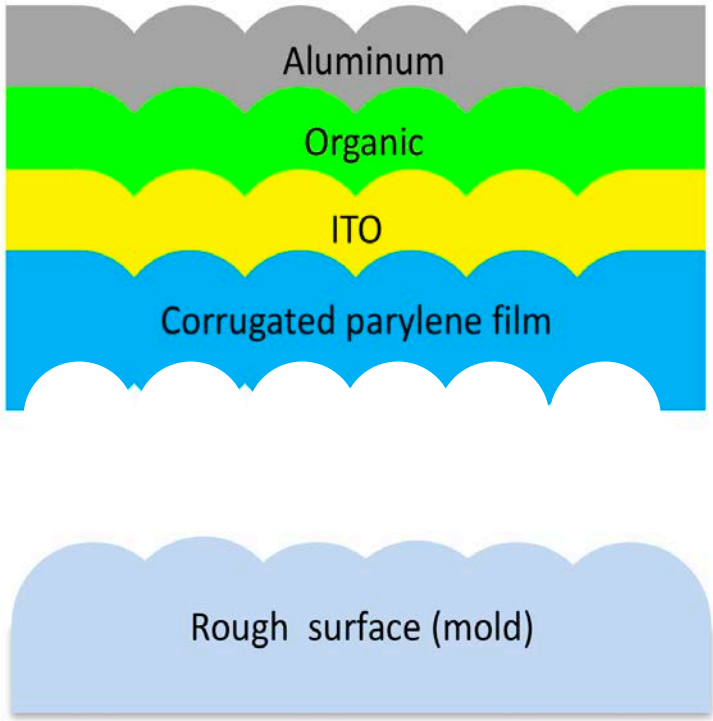
Organic structure: HatCN 30nm/ BPhen: Li 30nm/ Bphen 30nm / CBP : (acac)Ir(ppy)$_2$ 30nm/ TAPC 40nm / HatCN 30nm/

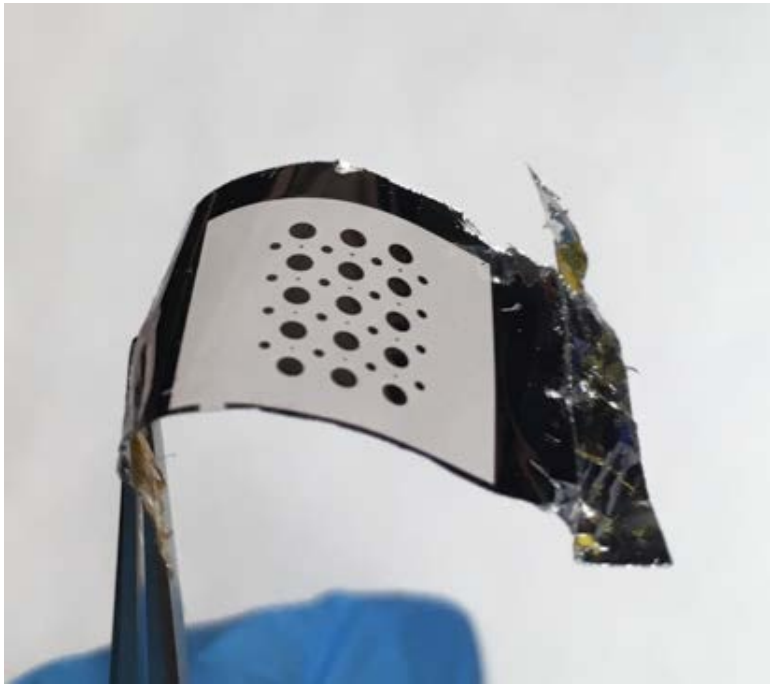






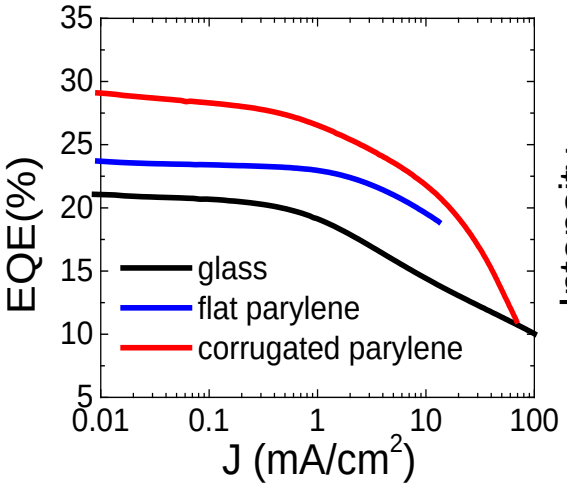
Flexible Corrugated Substrates

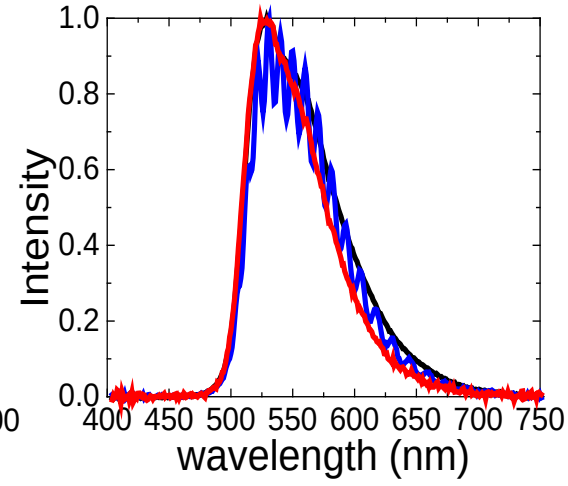


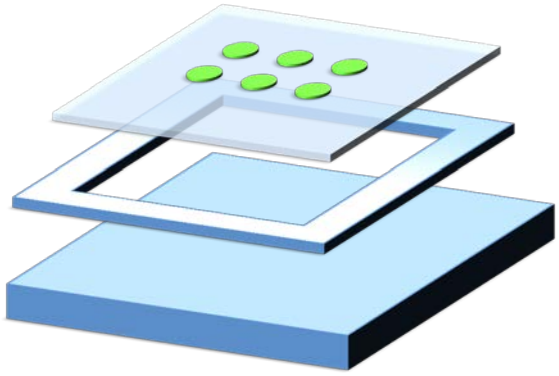


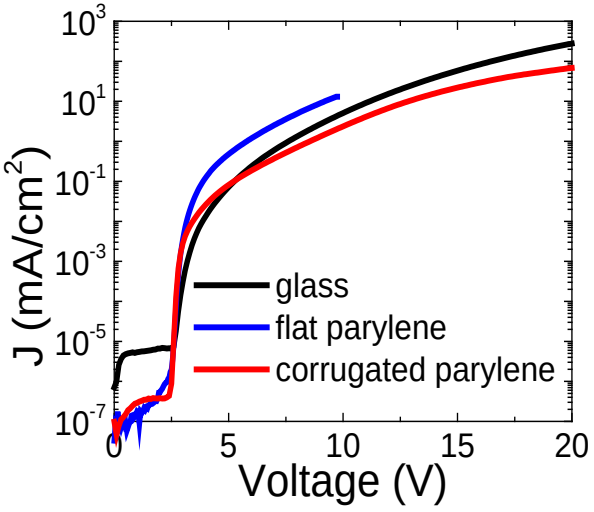
- ❑ Ultra-thin (~μm)
- ❑ Flexible
- ❑ Light extraction from substrate, waveguide and SPP modes

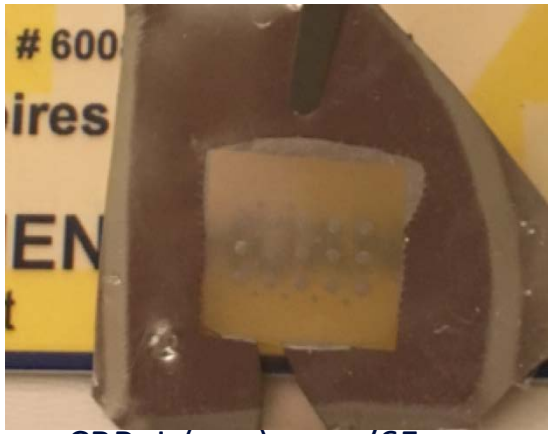
Flexible Corrugated Substrates







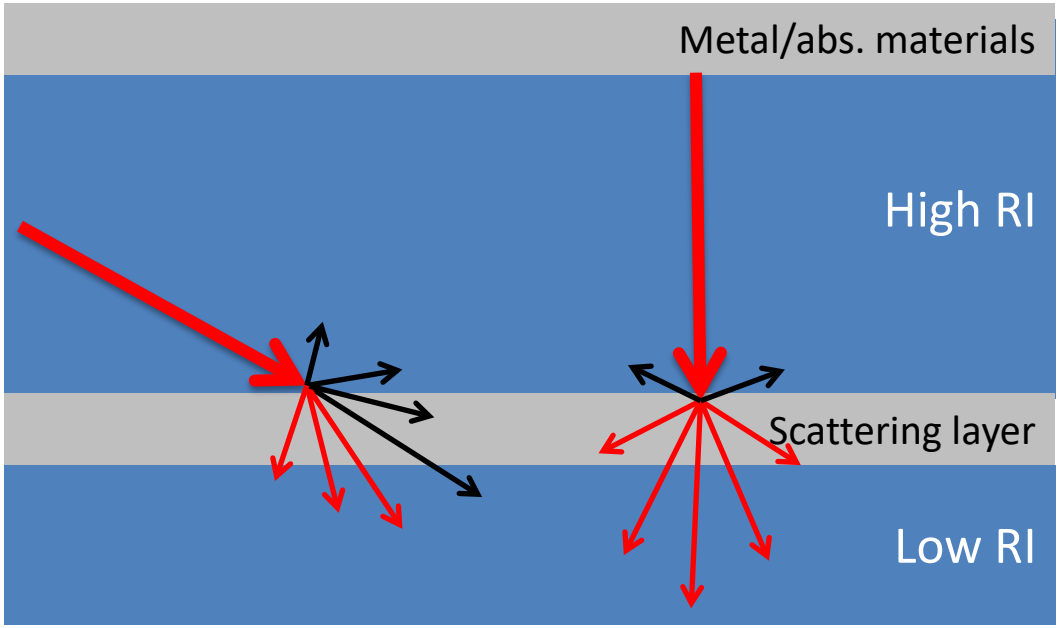




70nm ITO/2nm MoO_3/40nm TAPC/25nm CBP: $Ir(ppy)_2acac$/65nm TPBi/LiQ/Al

Conclusions & Discussions

- ❑ Four light extraction methods
- ❑ Non-intrusive structures can be better in light extraction
- ❑ Substrates integrated with outcoupling structures are applicable for both top and bottom emitting OLEDs
- ❑ Wavelength & angle independent outcoupling methodes



Acknowledgements

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