



Charge Balance – Key to High Efficiency OLEDs

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Project Title:
***High efficiency OLEDs with Down-
Conversion Phosphors***



Is there a correlation between winning the national championships and winning DOE contracts??

Acknowledgements

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Sanghyun Eom

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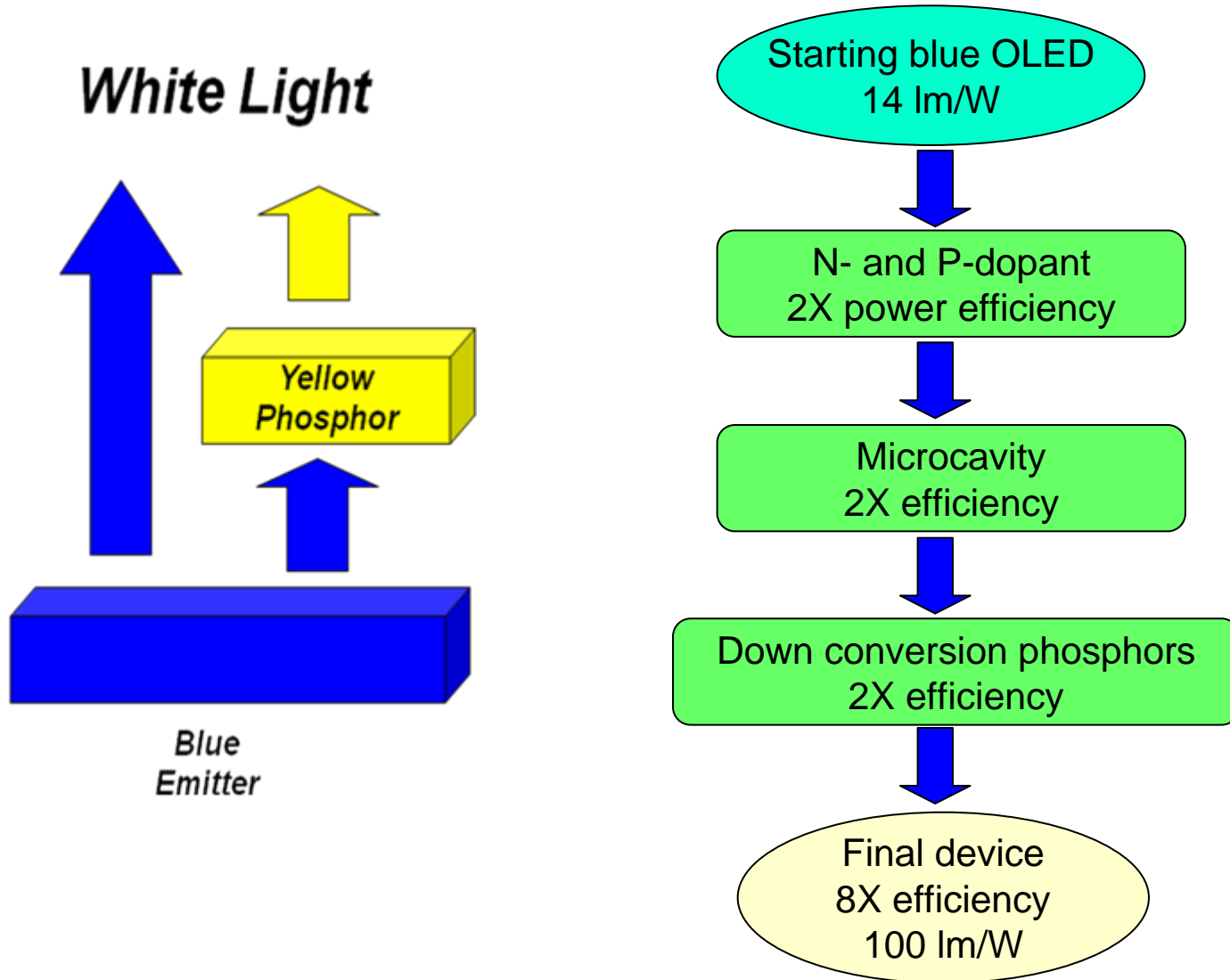
Sergey Maslov

Ying Zheng

Program Objective

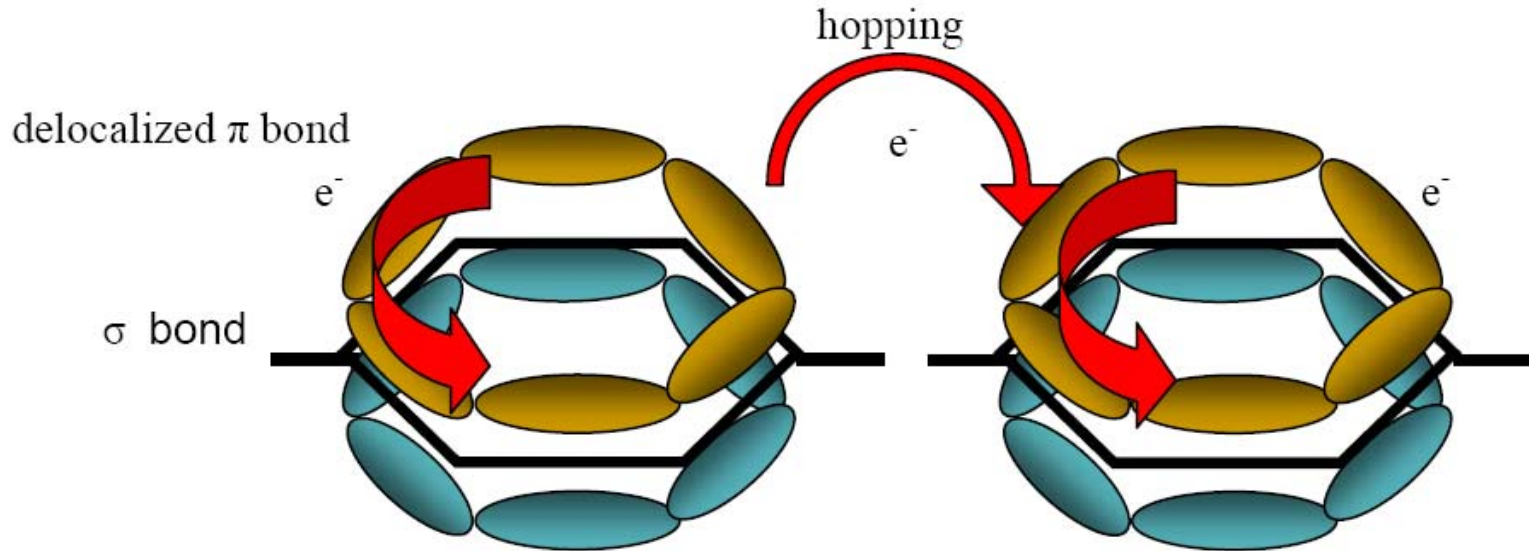
- To demonstrate high efficiency OLED devices with integrated microcavity structure and down conversion phosphors.
- The main focus of this work will be on three areas:
 - demonstration of high efficiency blue *OLEDs*
 - demonstration of OLED devices incorporated microcavity structure
 - demonstration of efficient *down-conversion* (from blue to white) using phosphors.

Technical Approach



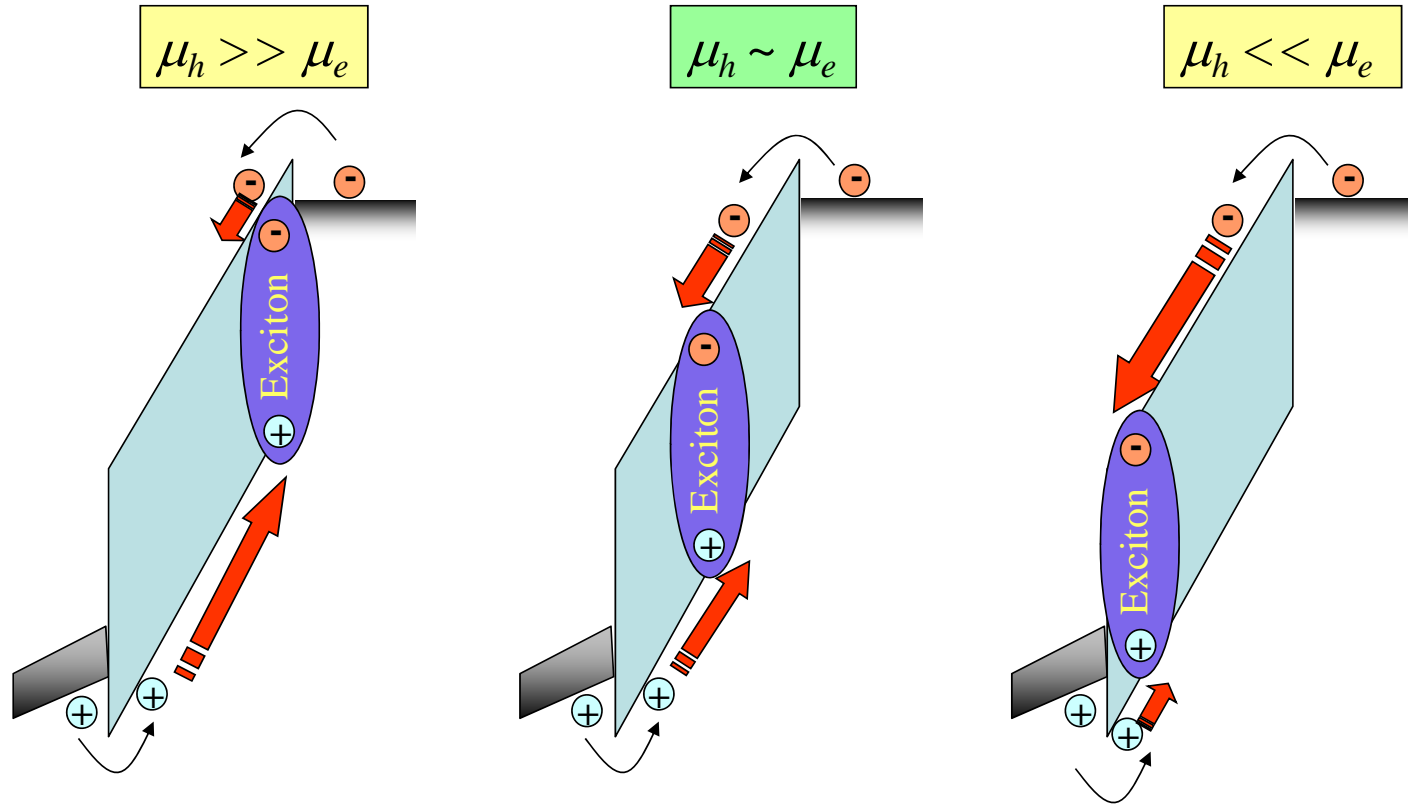
Charge Balance in OLEDs?

Charge transport in organic materials



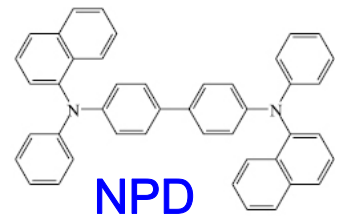
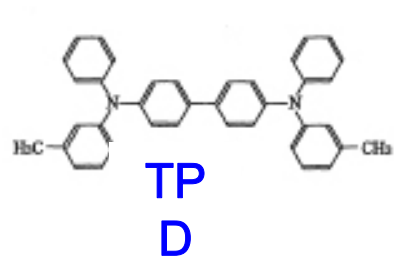
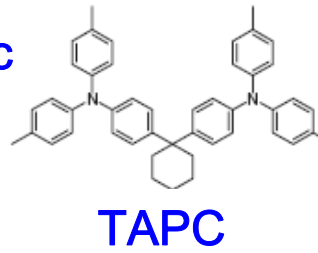
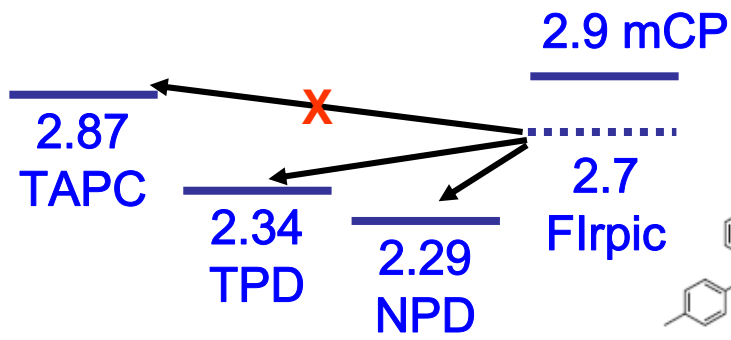
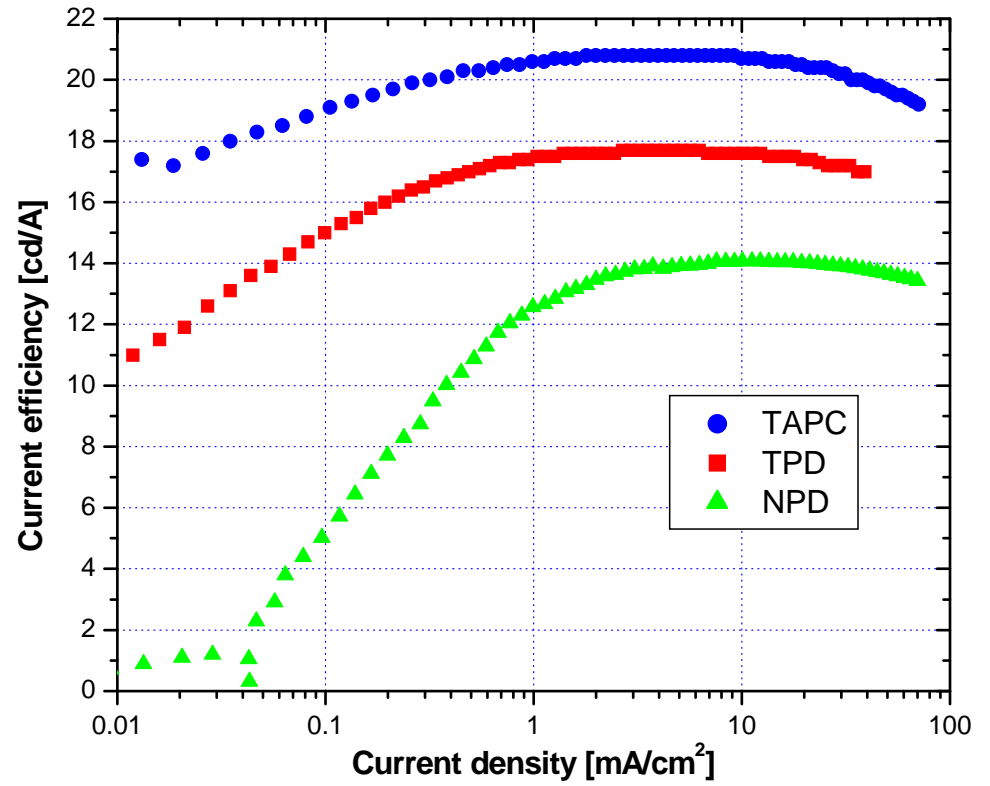
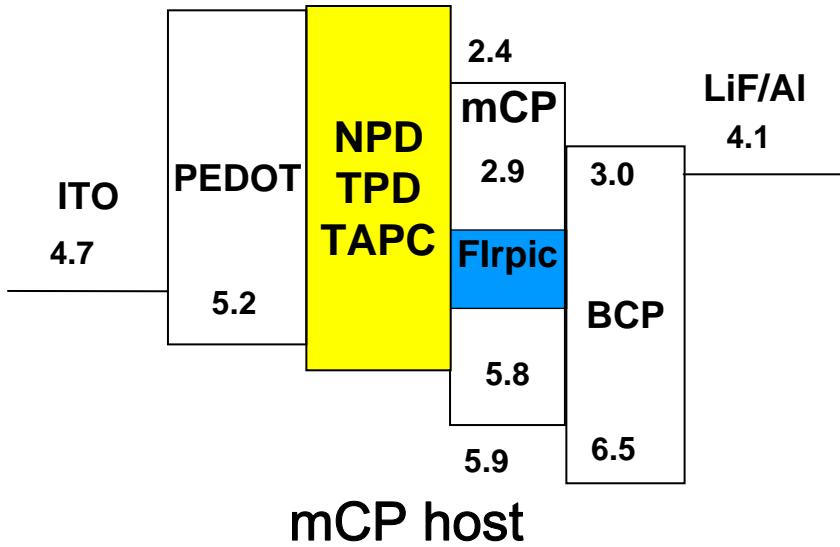
- *Electronic states are highly localized*
- *Charge transport by hopping*
- *Very low carrier mobility ($10^{-6} - 10^{-3} \text{ cm}^2/\text{Vs}$)*
- *Insensitive to impurities and defects*

Why is Charge Balance important in OLEDs?

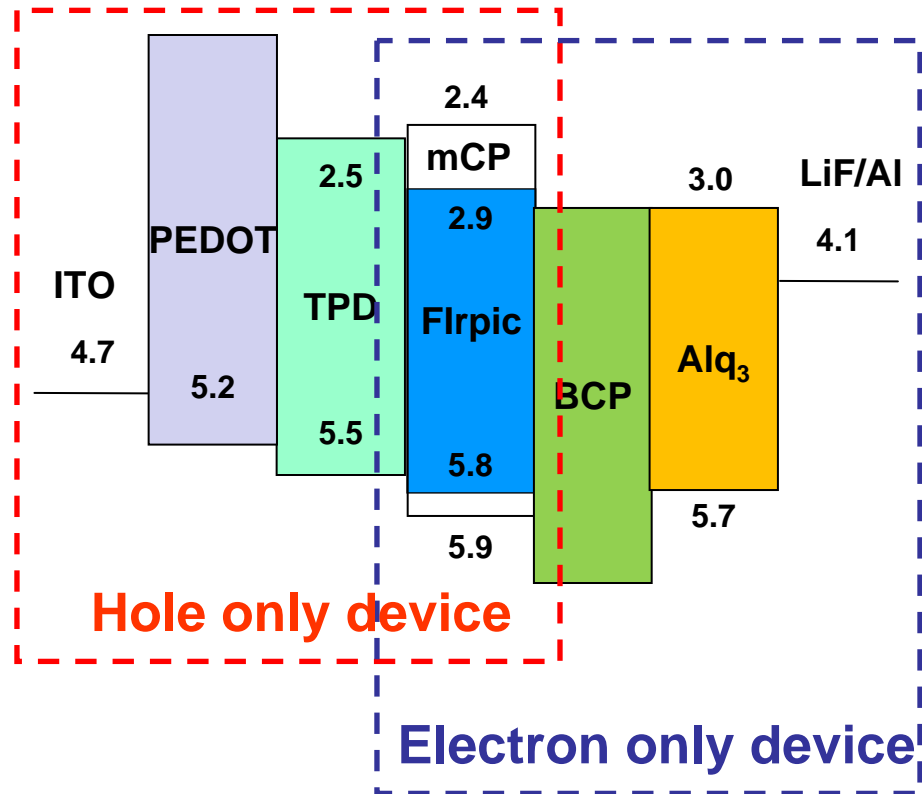


- *Imbalance in carrier transport*
 - *Charge accumulation at interface leads to exciton quenching*
 - *Carrier transport materials with low triplet energies lead to exciton quenching.*

Effects of triplet energy of hole transport layer

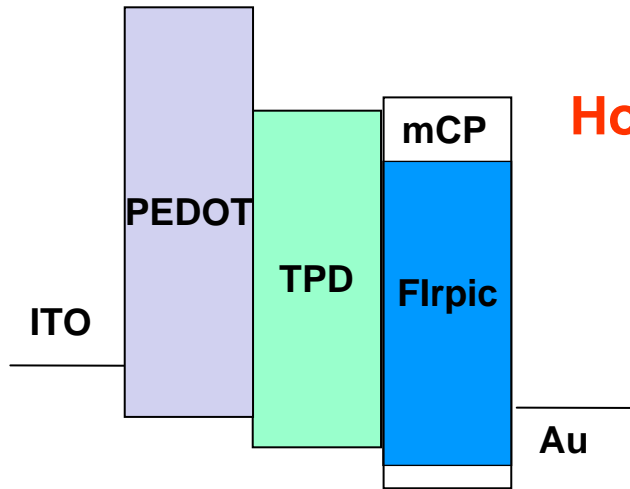


Charge imbalance

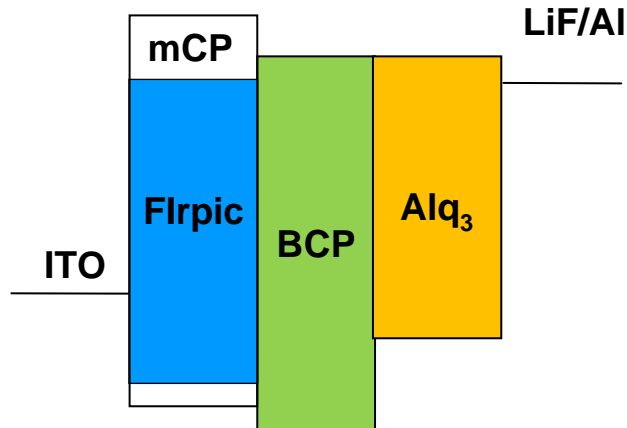


- Hole mobility of HTL: $10^{-3} \text{ cm}^2/\text{V-s}$
- Electron mobility of ETL: $10^{-5} - 10^{-6} \text{ cm}^2/\text{V-s}$

Single carrier devices

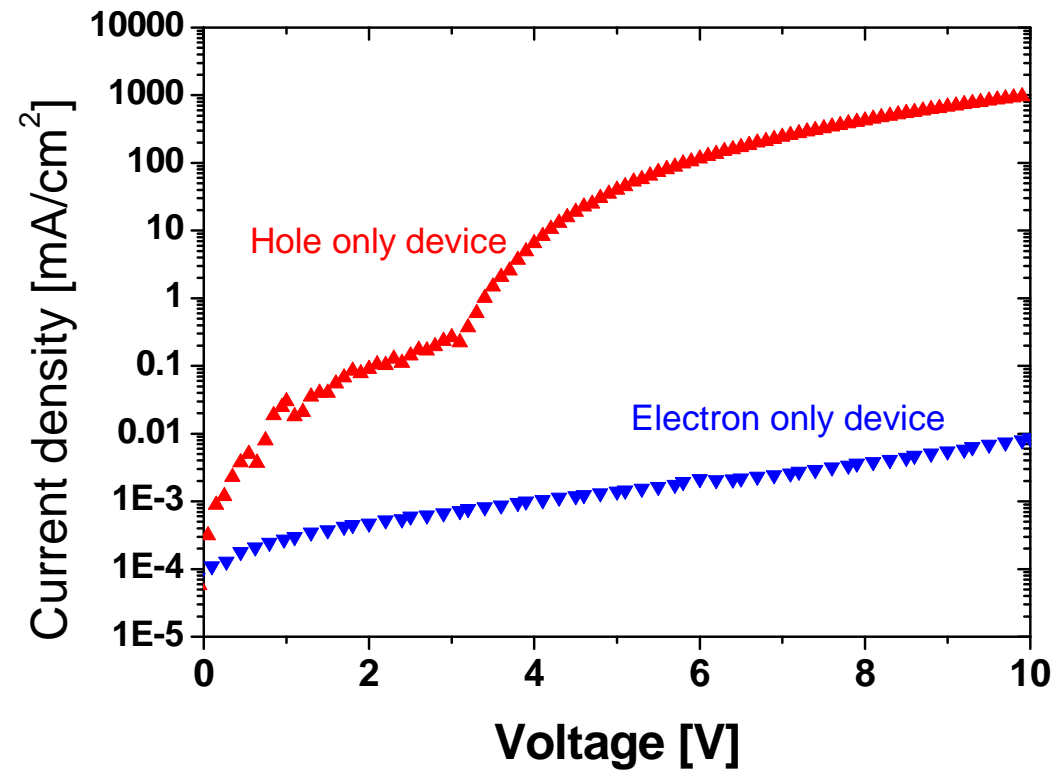


Hole only device

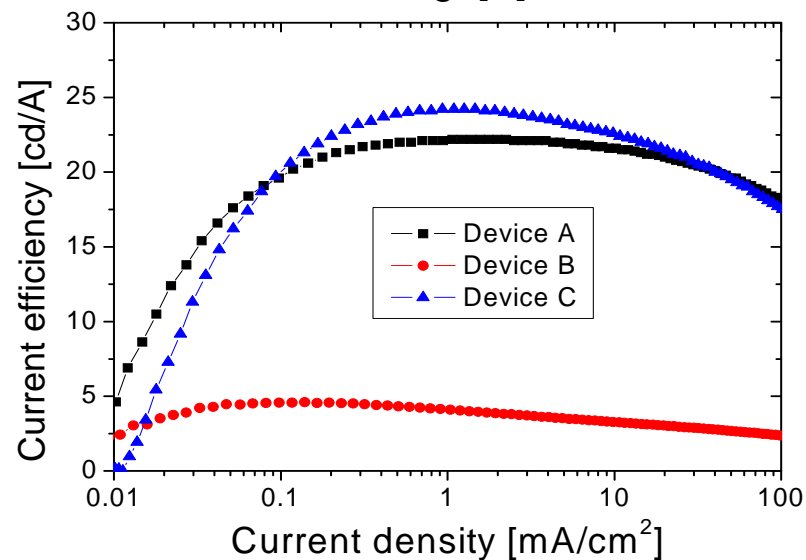
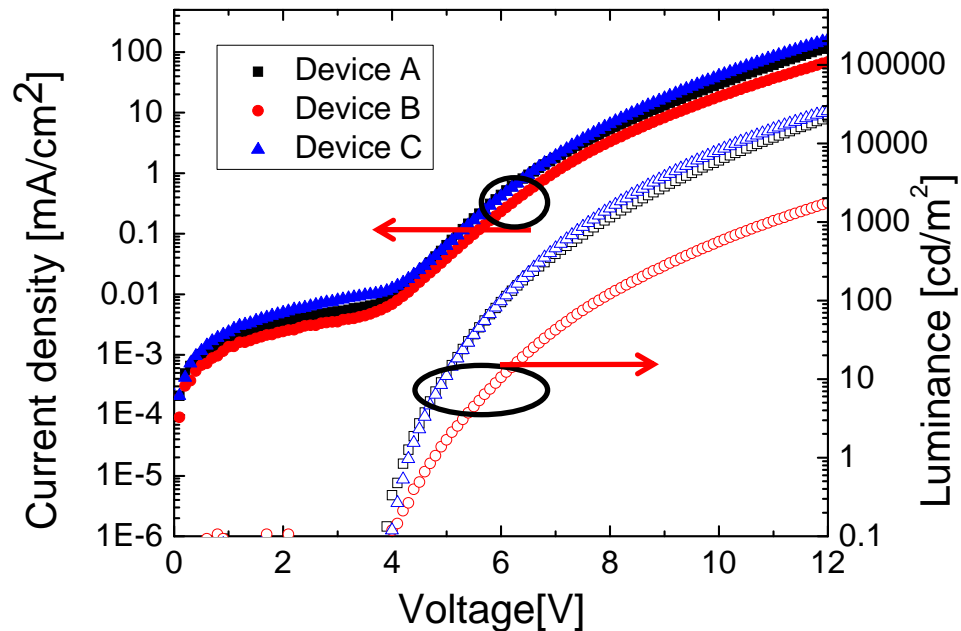
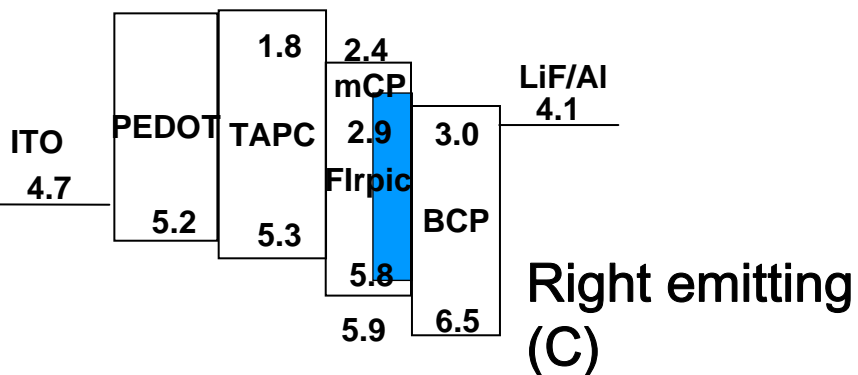
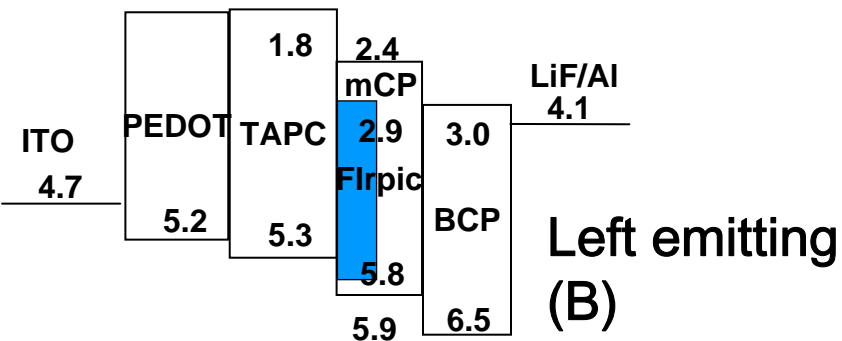
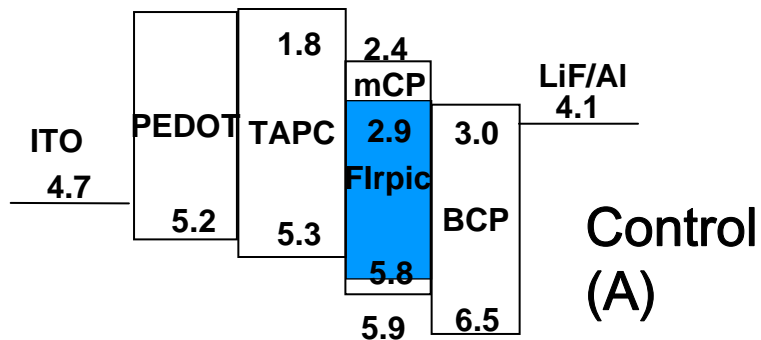


Electron only device

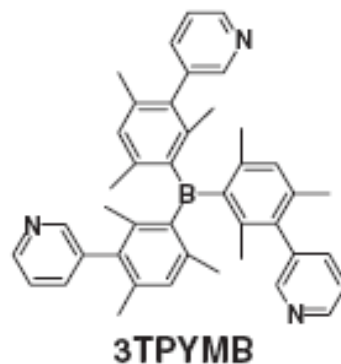
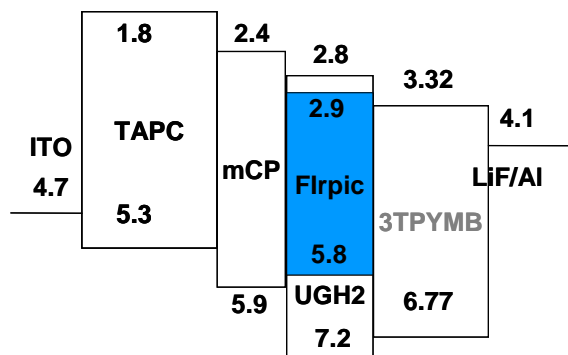
Hole current and electron current



Effect of recombination zone

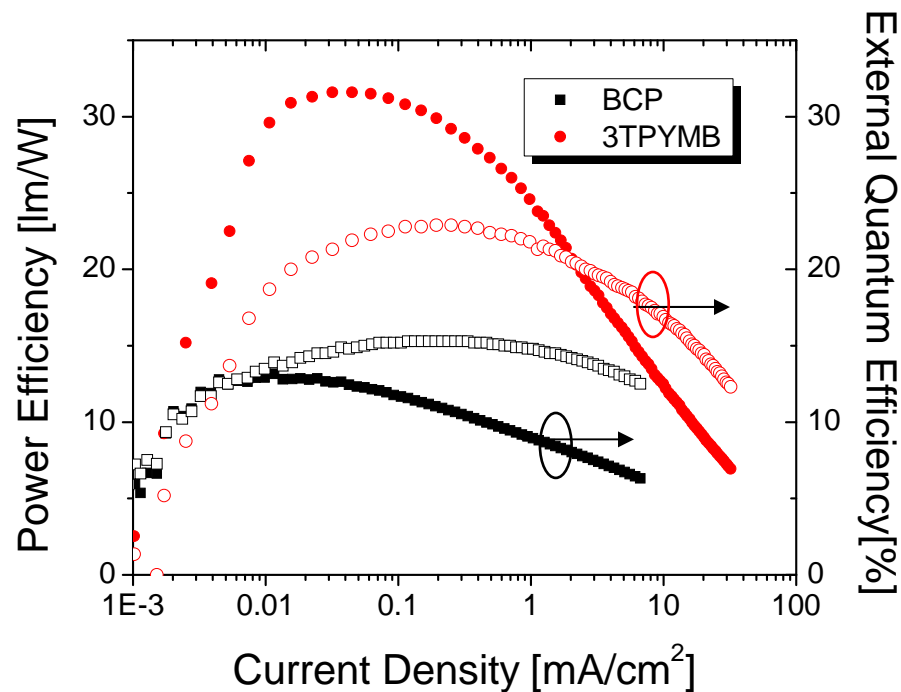
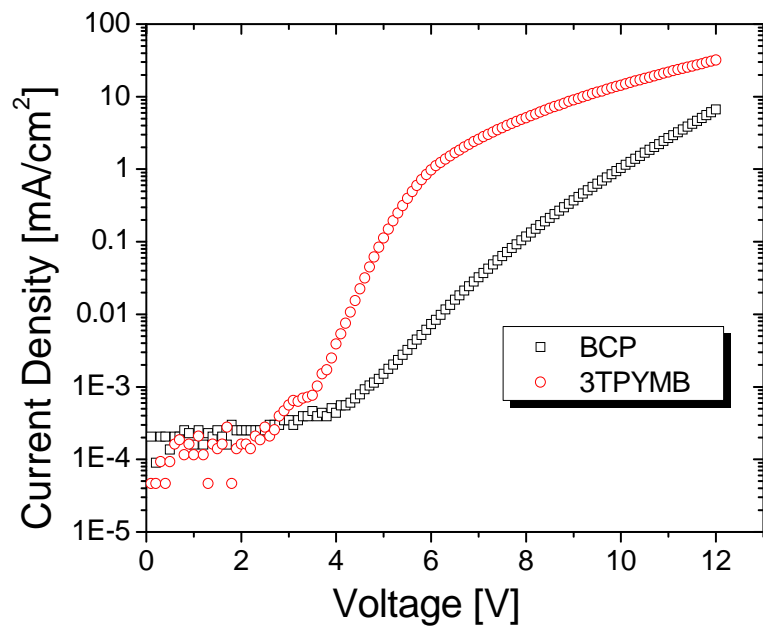


Device with improved electron transport

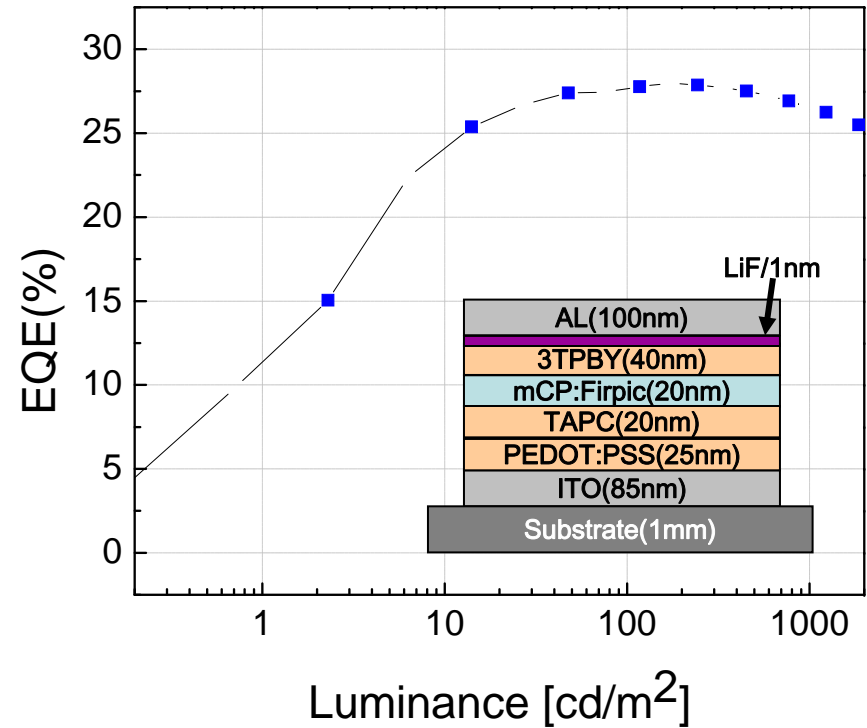
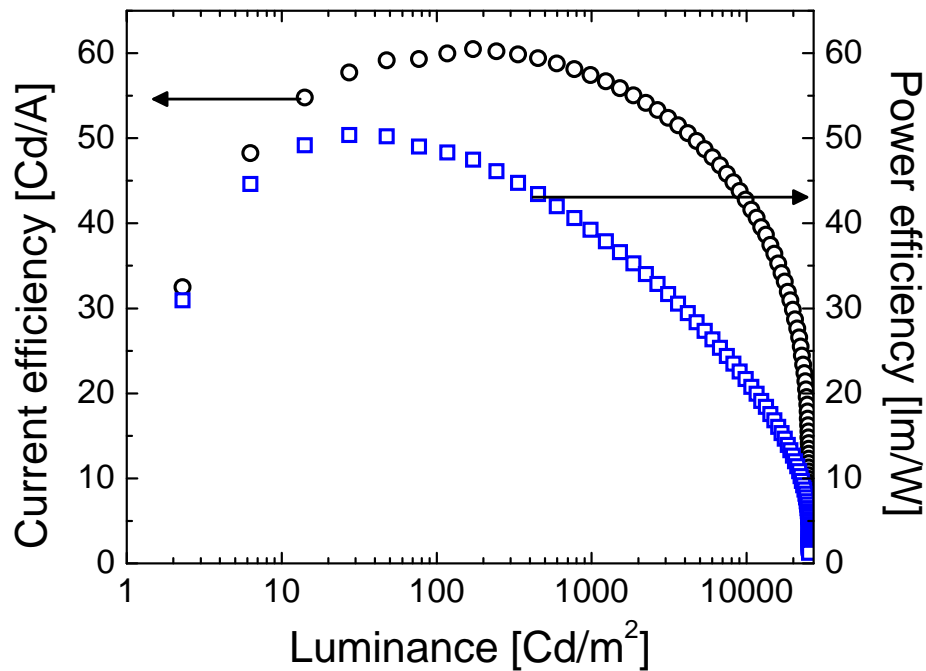


$$\mu_e \sim 10^{-5} \text{ cm}^2 \text{ V}^{-1} \text{ s}^{-1}$$

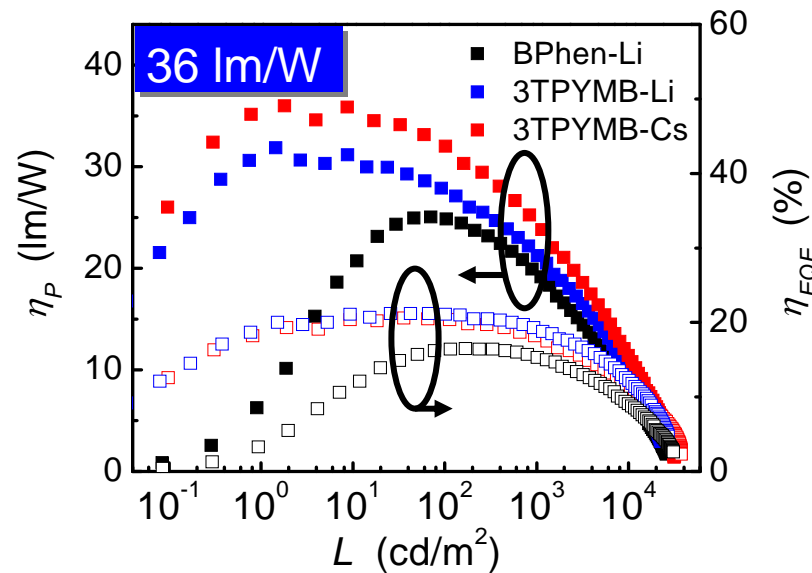
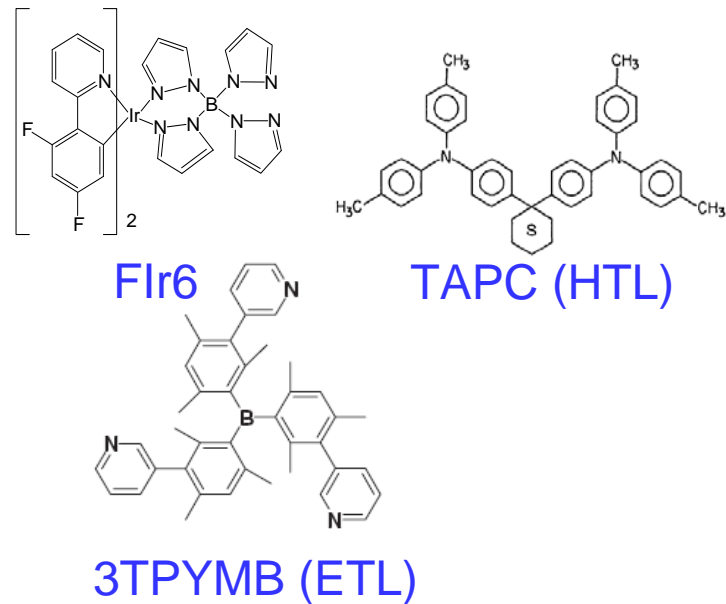
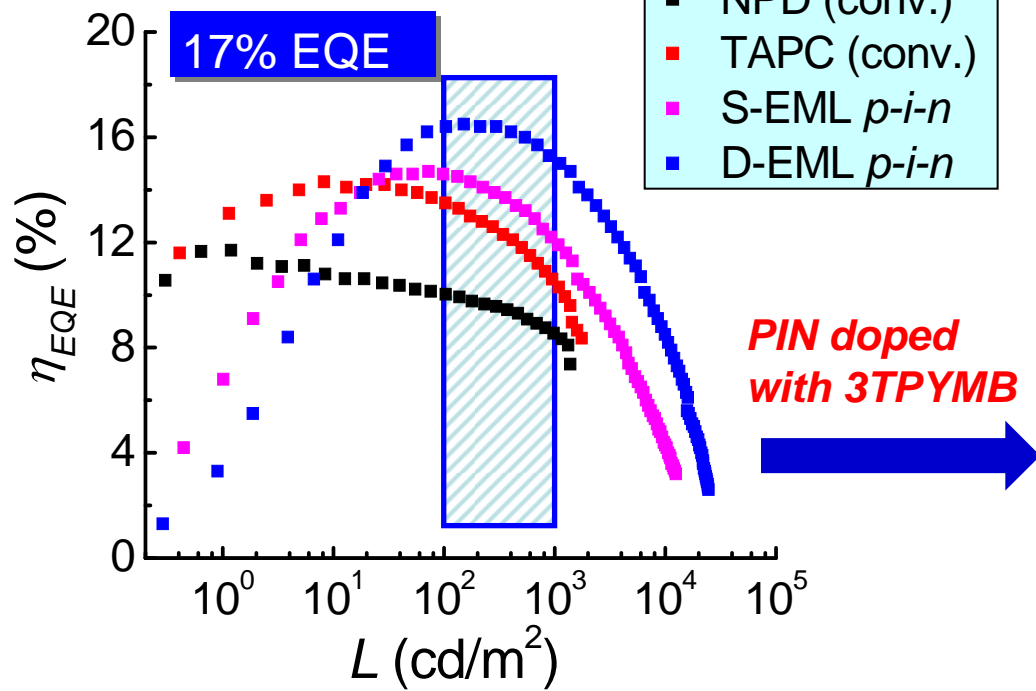
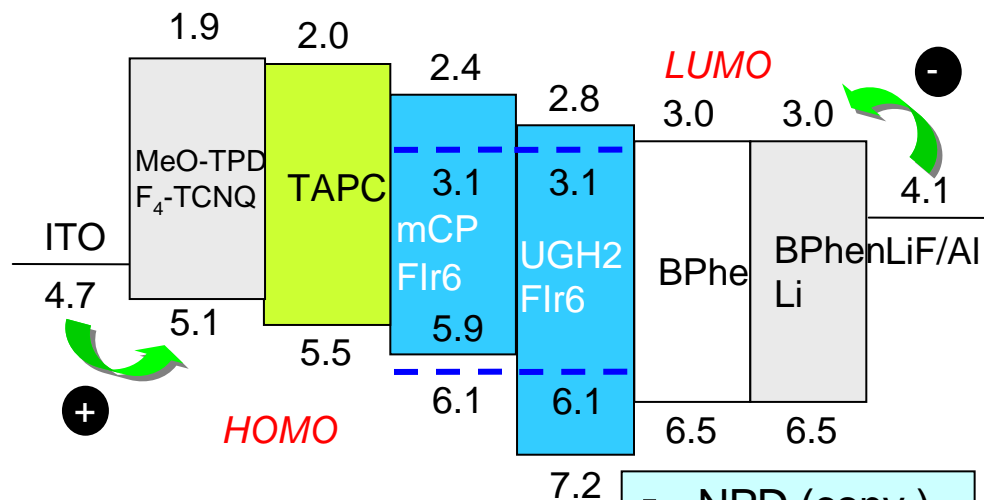
$$\text{Triplet energy} = 2.98 \text{ eV}$$



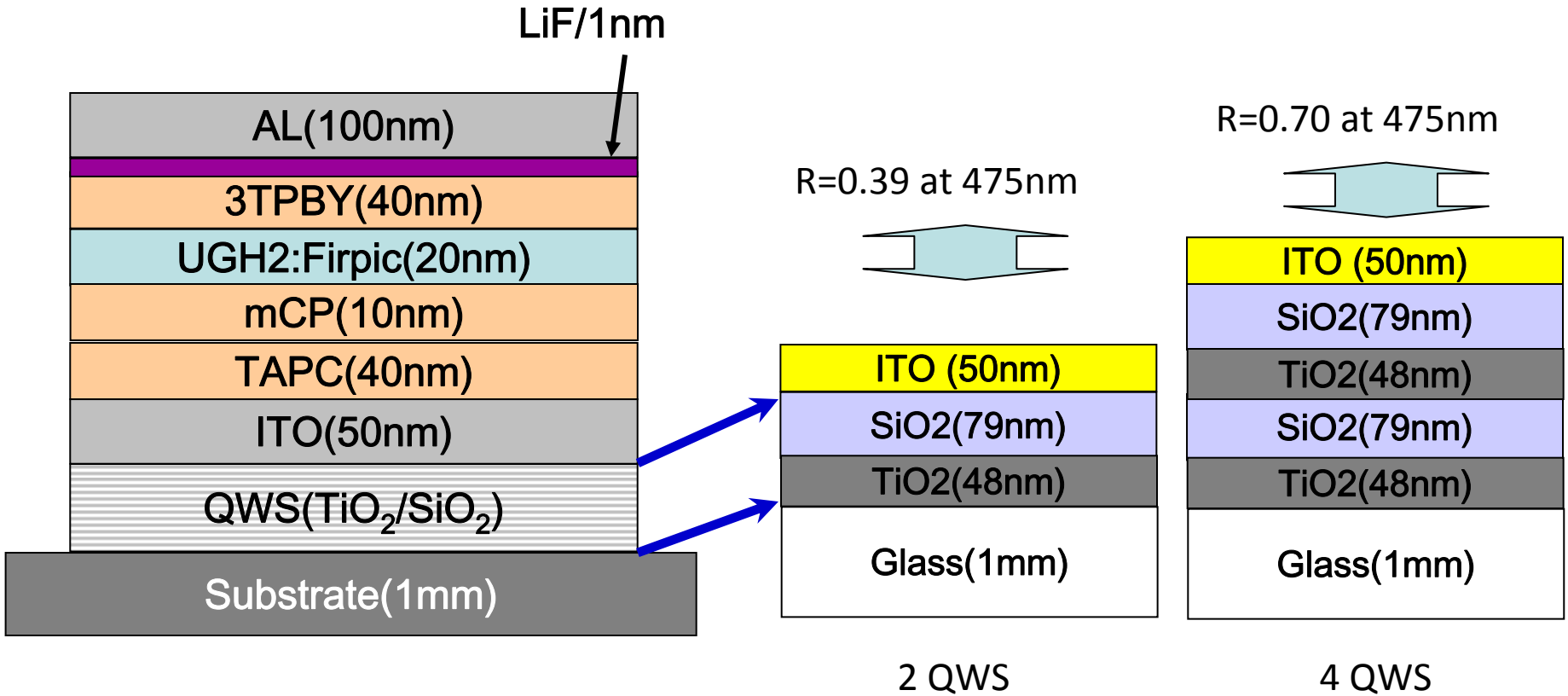
Further tuning the charge balance



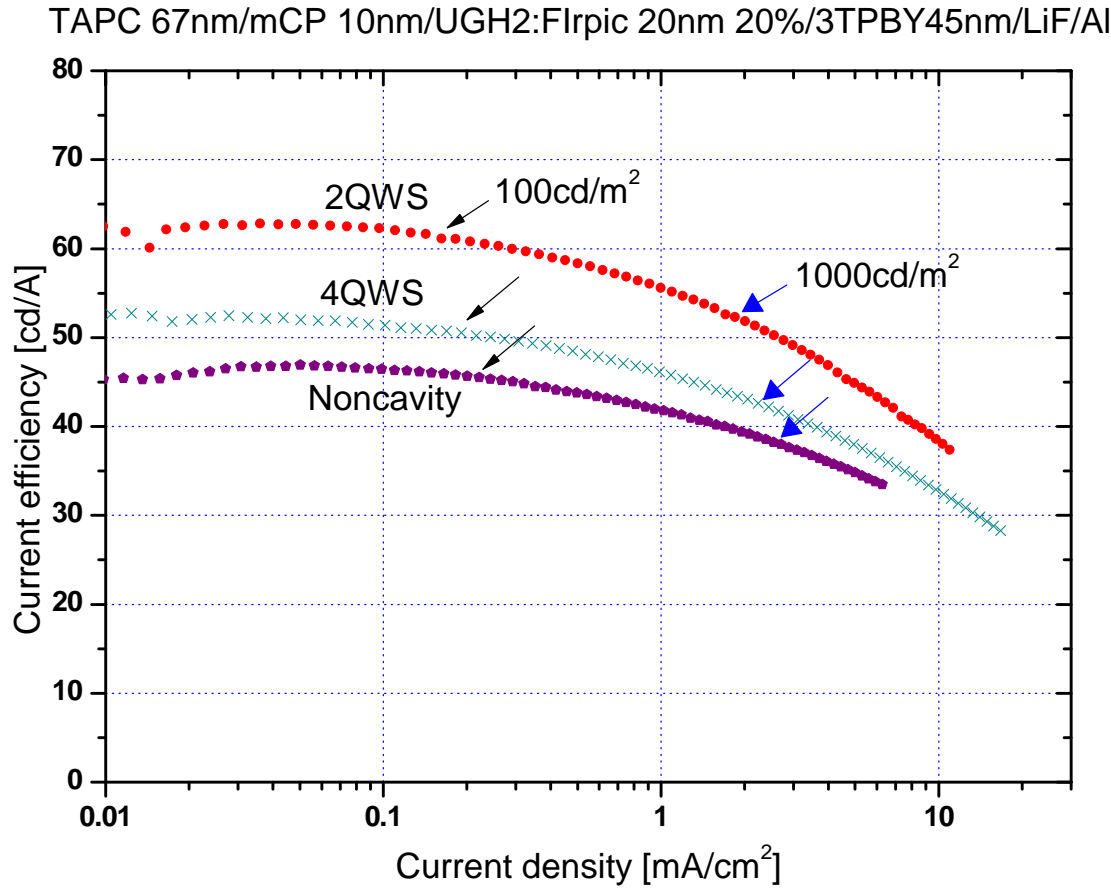
Effect of PIN structure



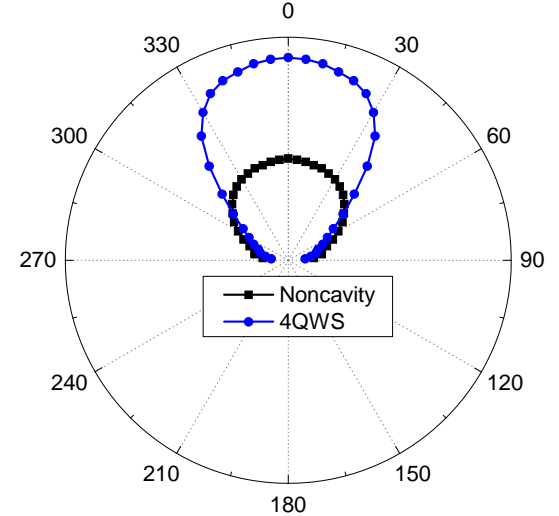
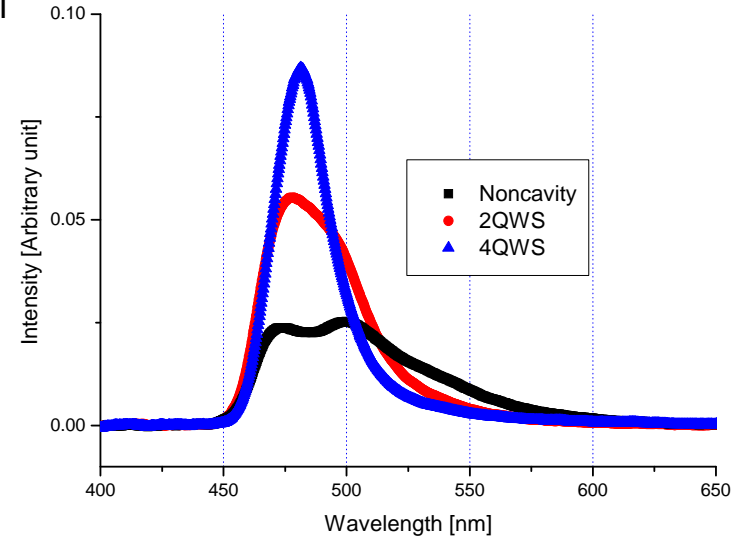
Microcavity OLEDs



Microcavity blue PHOLEDs

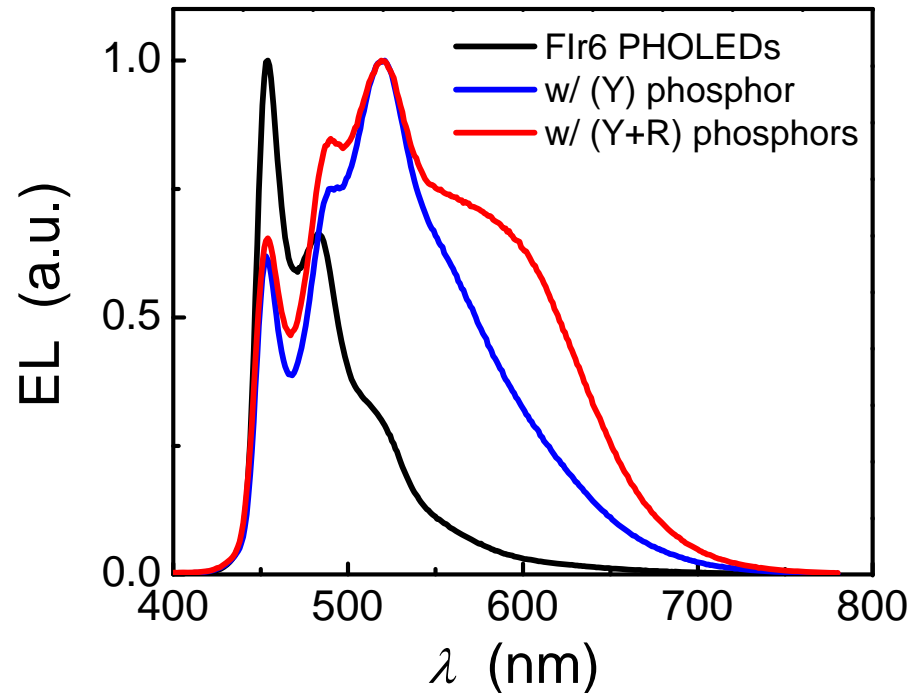
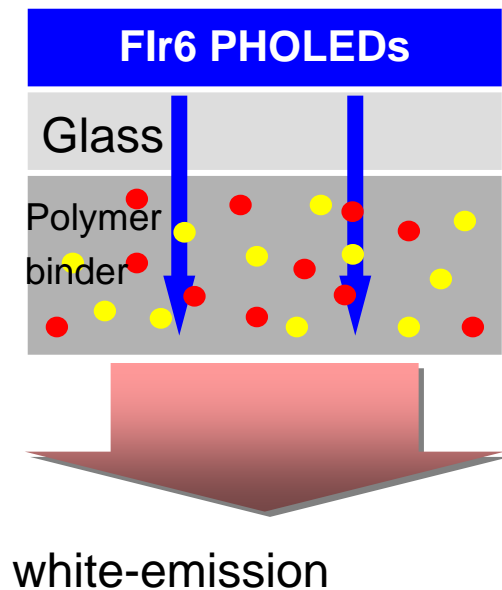


TAPC 67nm/mCP 10nm/UGH2:Flrpic 20nm 20%/3TPBY45nm/LiF/Al



Blue OLED with down-conversion phosphors

	Fir6 PHOLEDs	w/ (Y) phosphor	w/ (Y+R) phosphors
CIE (x, y)	(0.16, 0.25)	(0.32, 0.45)	(0.38, 0.43)
CRI	-	69	86



The last steps.....

