

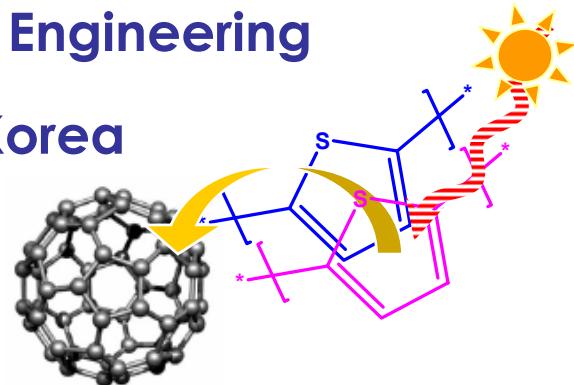


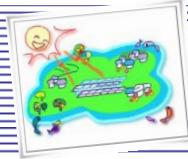
Improvement of Device Efficiency in Conjugated Polymer/Fullerene Nano- Composite Solar Cells

School of Semiconductor & Chemical Engineering

Chonbuk National University, Korea

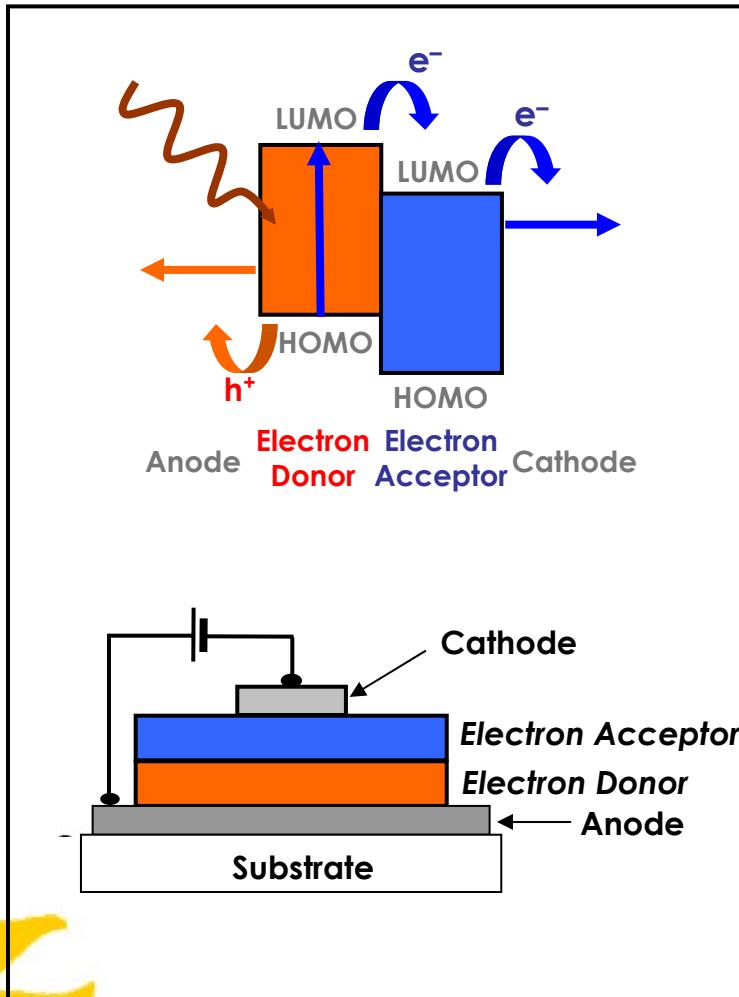
Soo-Hyoung Lee



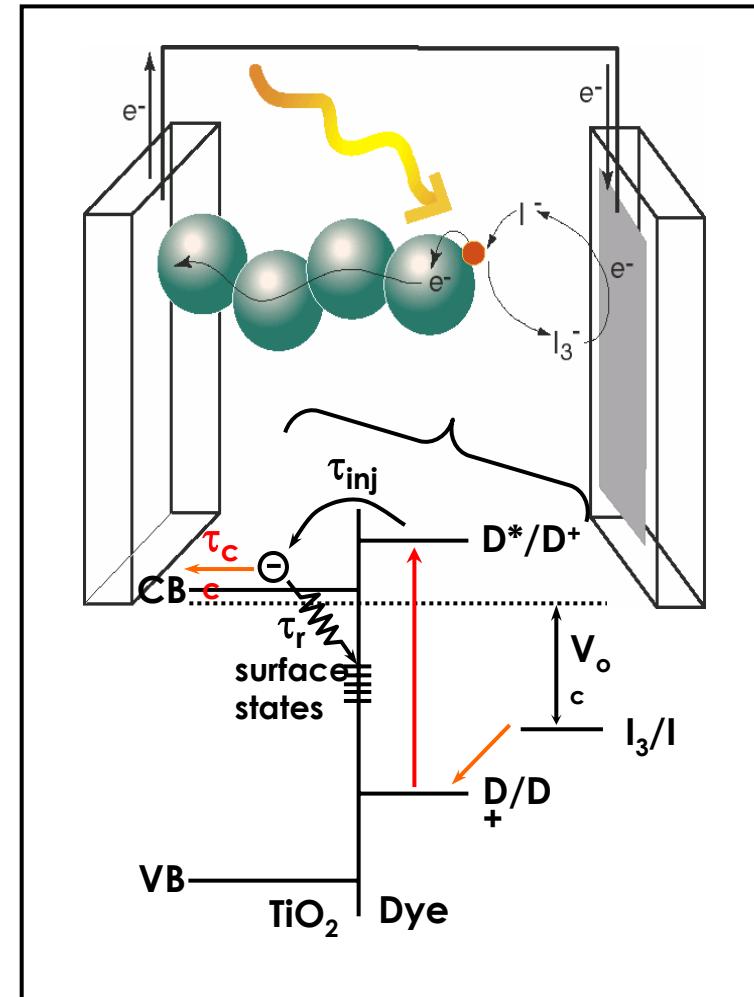


Organic Solar Cells

All Organic solar cell

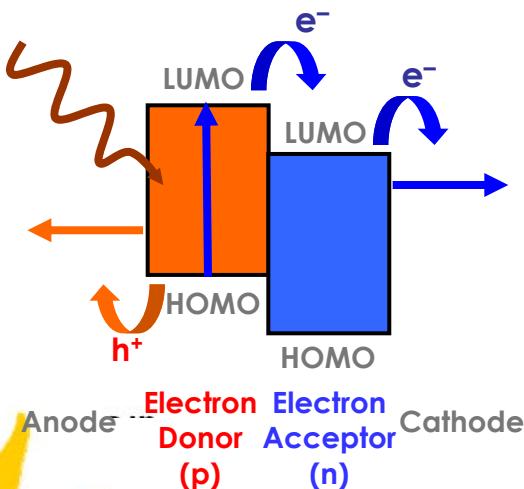
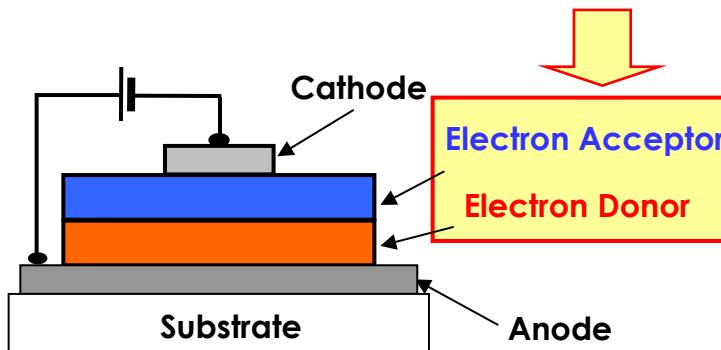


Dye-sensitized solar cell



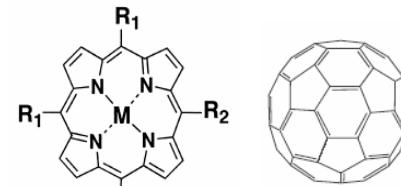
All organic solar cells

Type of Active Layer

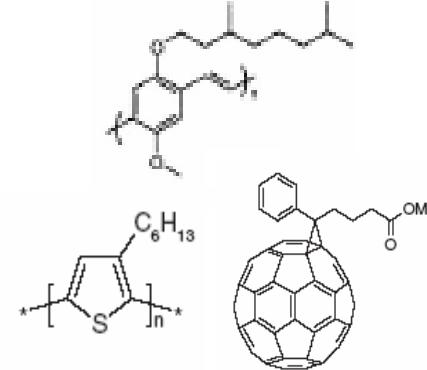


Material

Low Molecules

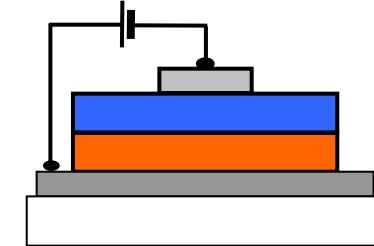


Polymers



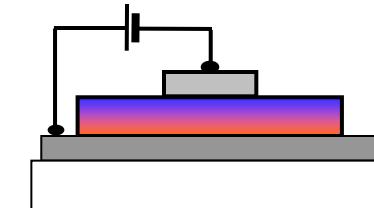
Structure

D/A Heterojunction



Double Active Layer

D/A Bulk Heterojunction

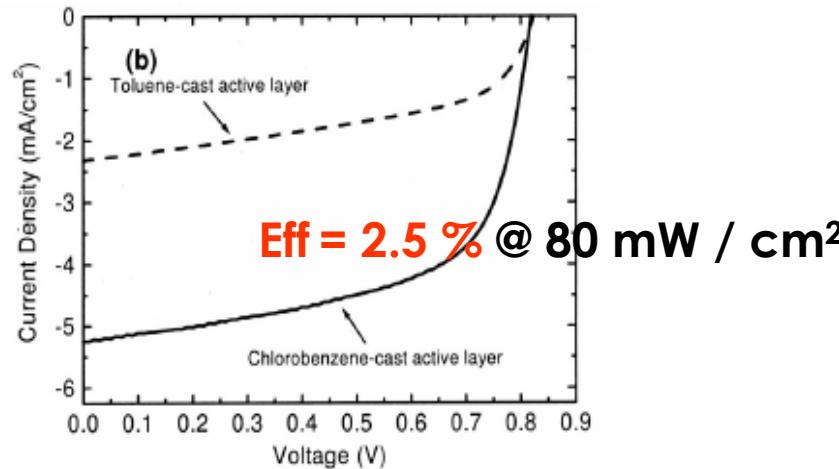
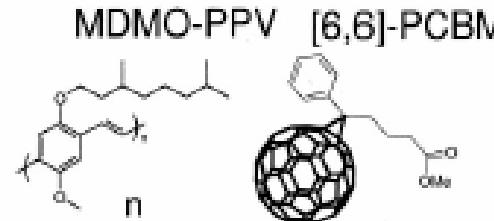
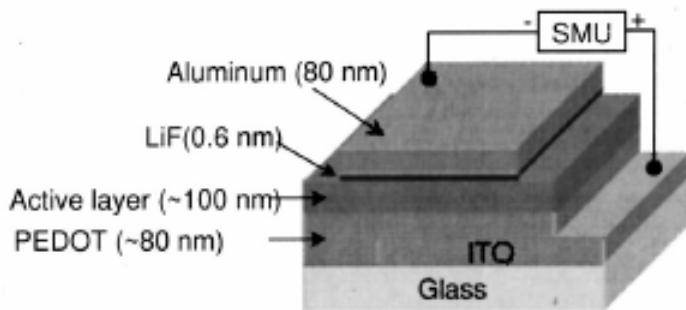


Single Active Layer

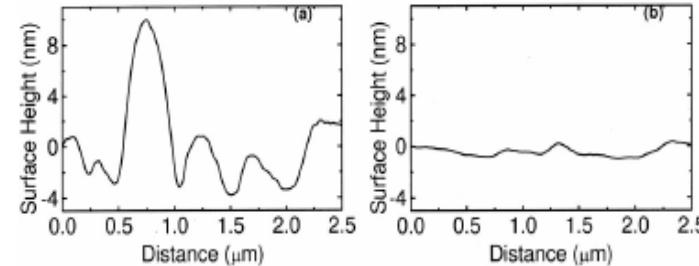
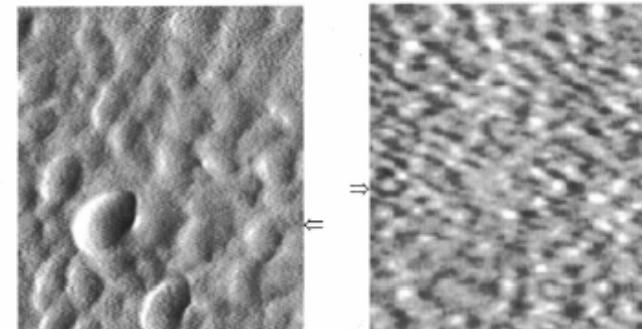
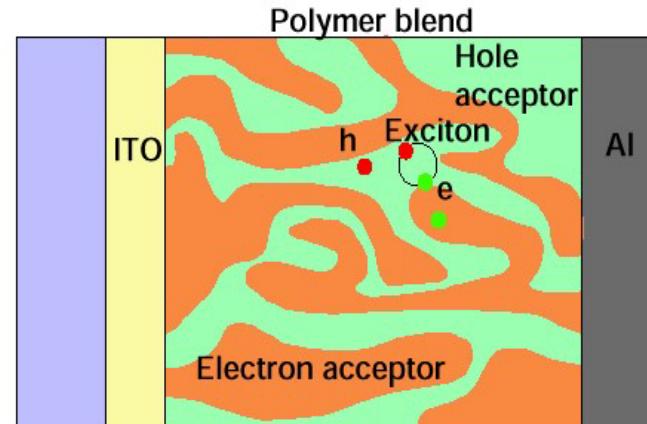




Polymer-Fullerene Solar Cell



Host matrix morphology effect

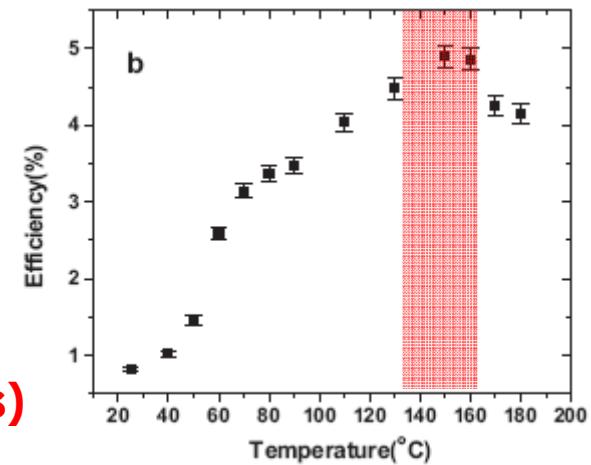
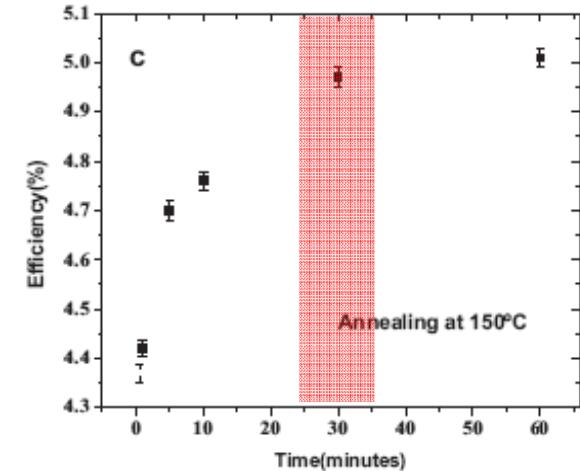
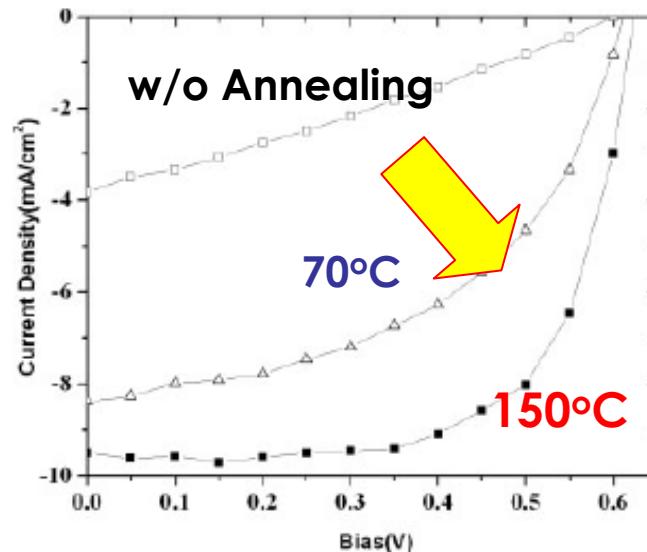
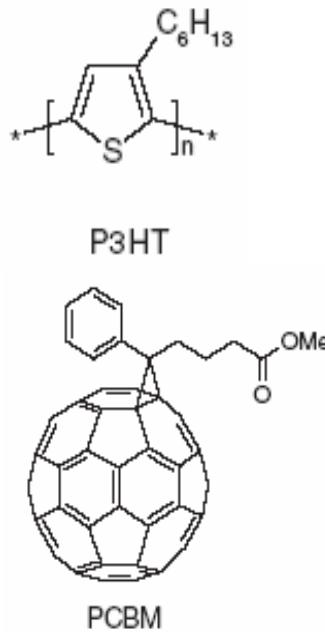


Sean E. Shaheen, et al., Appl. Phys. Lett. **78**, 841 (2001)





Polymer-Fullerene Solar Cell



ITO / PEDOT / P3HT:PCBM / Al

Eff = 5 % @ 80 mW / cm²

(Annealing after Al deposition 150°C for 30 mins)

Heeger et al., Adv. Funct. Mater., **15**, 1617 (2005)





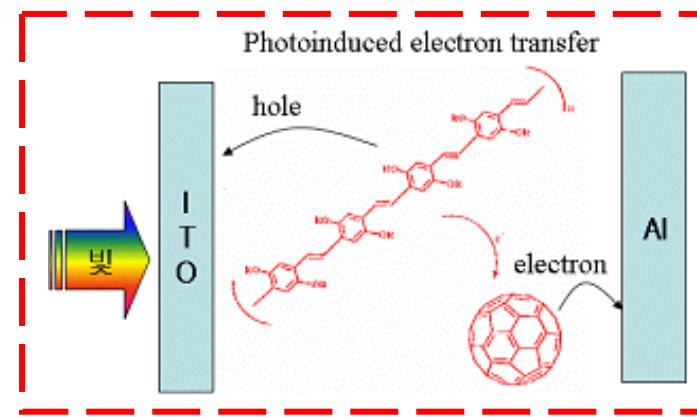
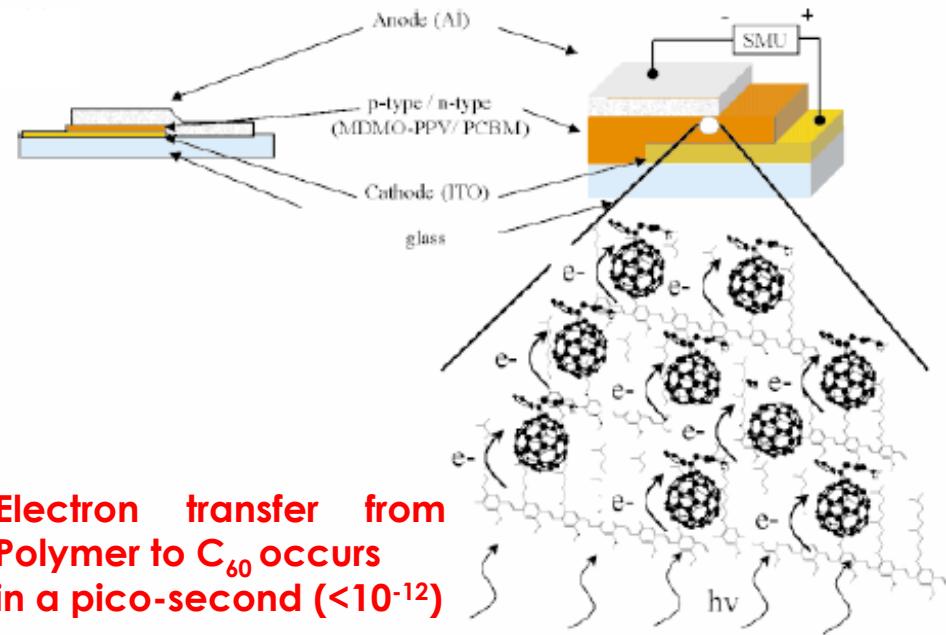
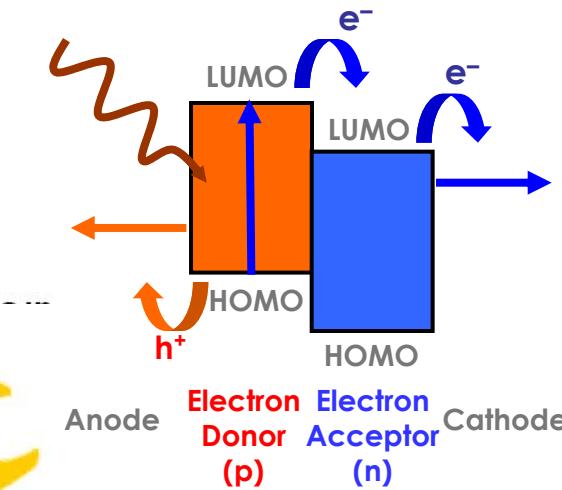
Polymer-Fullerene Solar Cell

❖ Total thickness of active layer : < 100-150 nm

D/A Bulk Heterojunction (Single layer)

❖ Maximum Efficiency: ~ 5 %

- ❖ Nano-composited interpenetrating network (IPN) structure
- ❖ Photoinduced charge generation in a 3D-network interfaces
- ❖ D/A Bulk-heterojection (BHJ):
 - Electron-donor (p-type): conjugated polymers
 - Electron-acceptor (n-type): fullerene (derivatives)

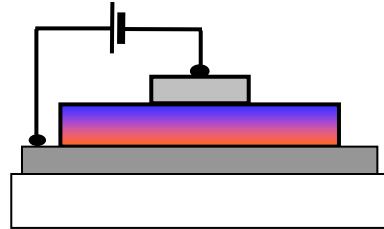




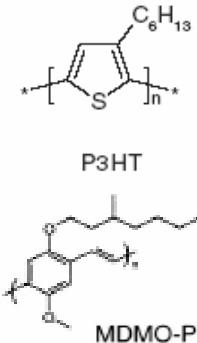
Polymer-Fullerene Solar Cell

How to make efficiency improvements?

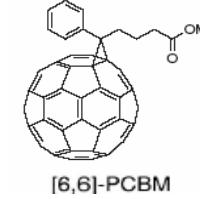
D/A Bulk Heterojunction



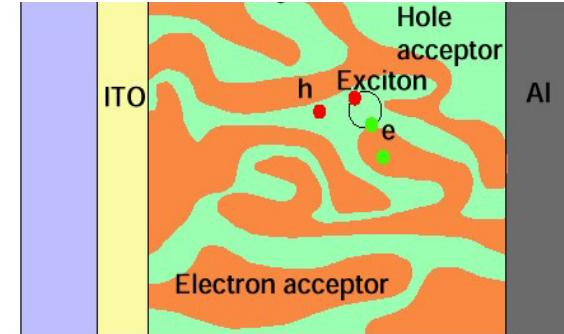
p-type



n-type



Nano-composited IPN structure



High

EFF

J_{sc}
 V_{oc}
FF

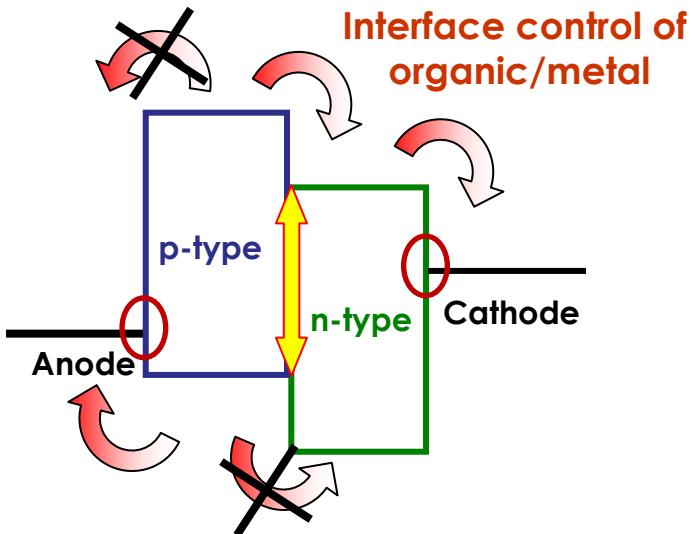
High
Absorption
Separation
Transportation

Materials

Bandgap (Eg)
HOMO & LUMO
Crystallinity
ETC...

Mechanism

Devices
Structure
Treatment
Additives
ETC...



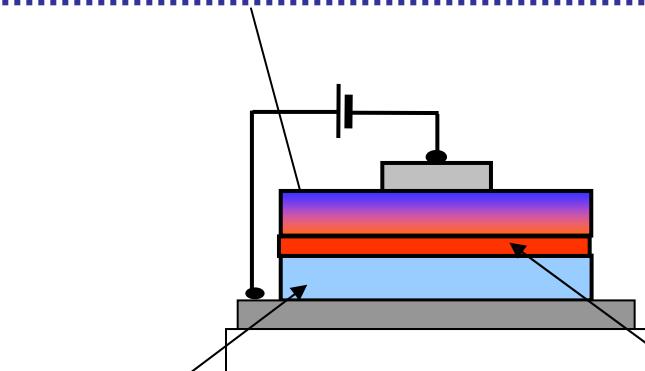
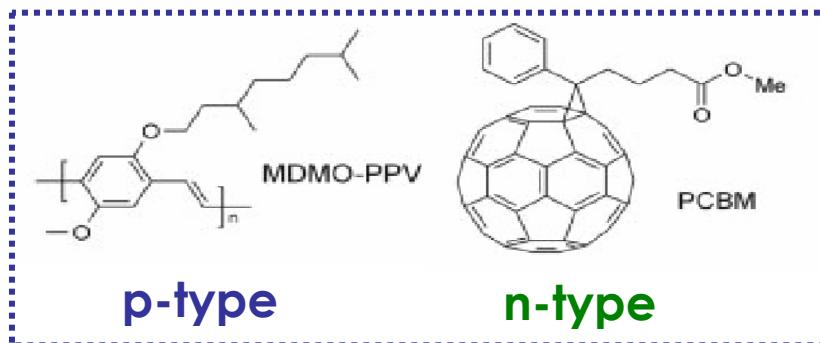
Effective charge transportation / collection



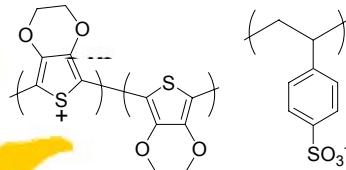
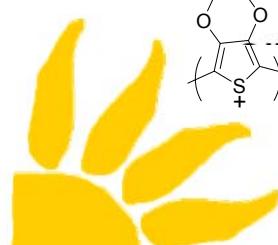
Approach # 1

Efficient solar cells with interlayer

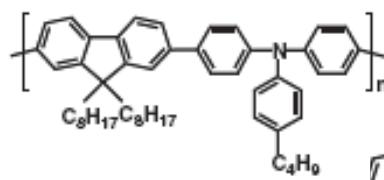
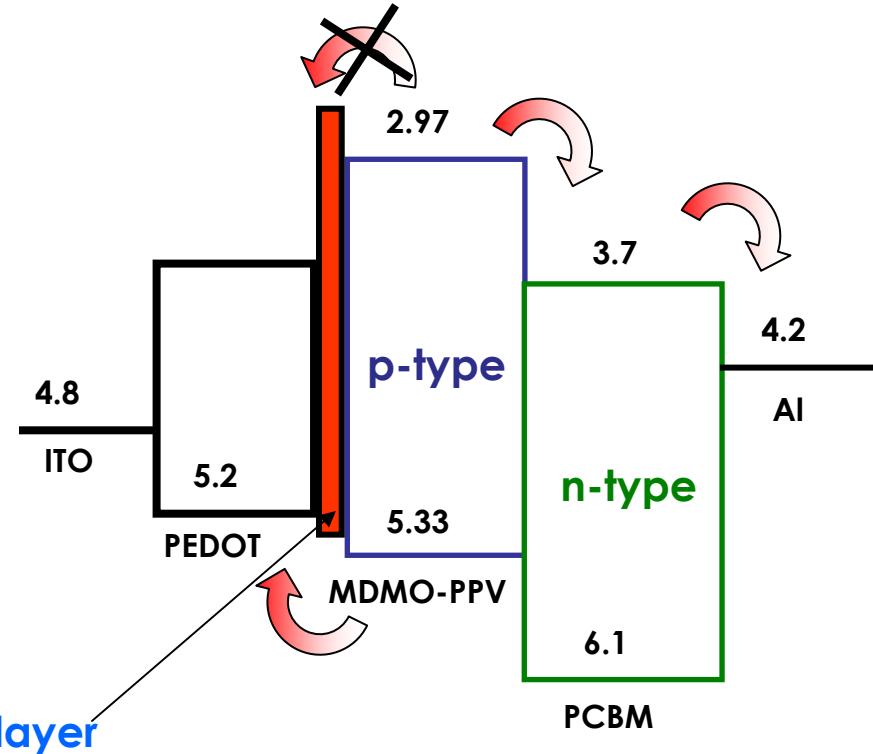
D/A Bulk Heterojunction



PEDOT:PSS



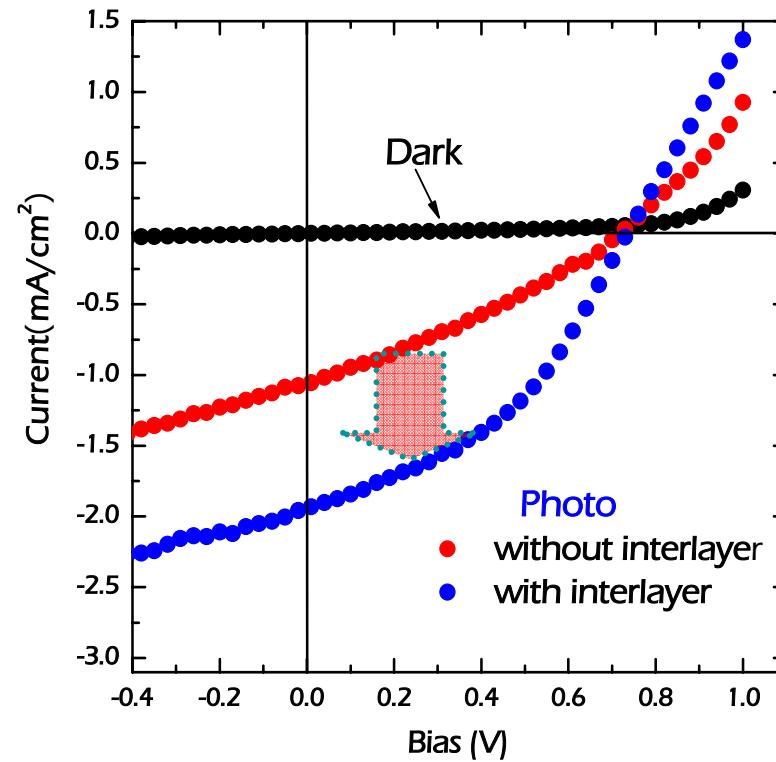
Interlayer (~ 10 nm): blocking of electron & exciton from active layer





Approach # 1

Efficient solar cells with interlayer



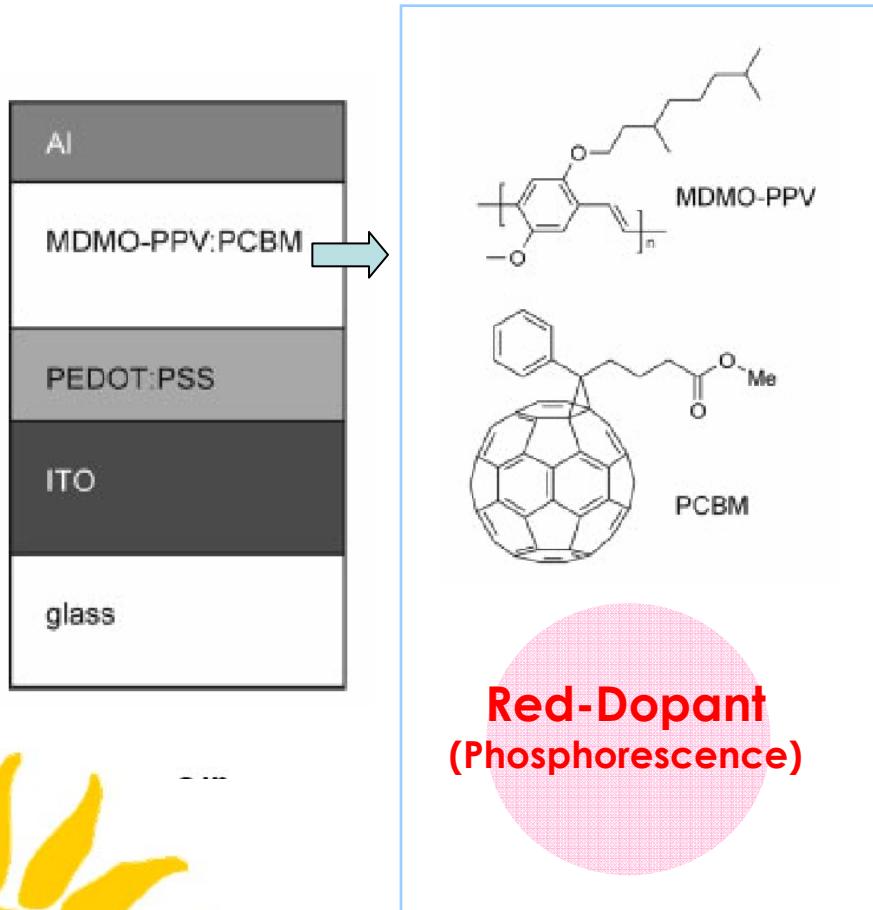
	Voc(V)	Jsc(mA/cm^2)	FF	EFF(%)
without interlayer	0.72	-1.062	0.301	0.229
with interlayer	0.73	-1.940	0.409	0.583



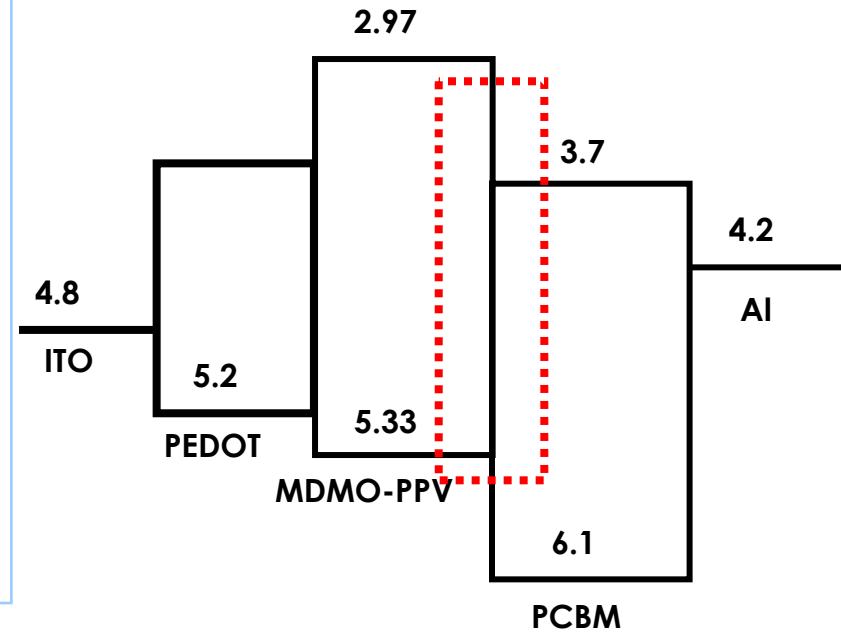
Approach # 2

Use of Triplet (Phosphorescence) Organic Materials

- Conventional polymer-fullerene organic solar cell (PPV-PCBM system)
+ SM Red-Dopant



MDMO – PPV : p-type material
PCBM : n-type material
Red-Dopant : absorber & ET (long lifetime)

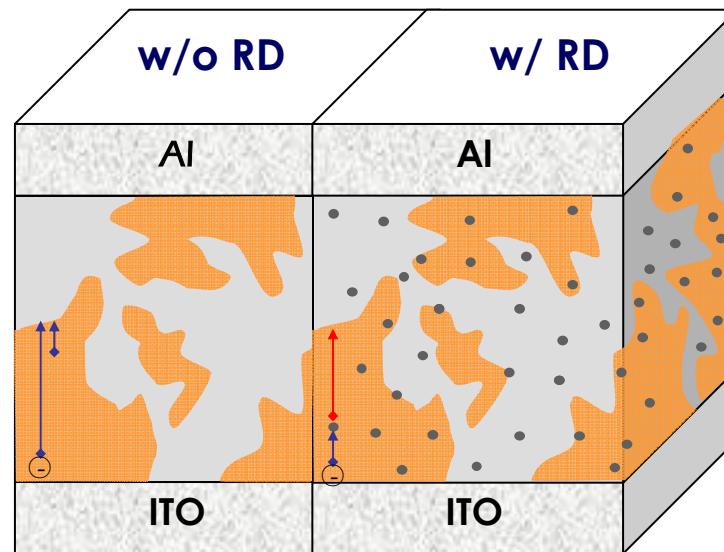




Approach # 2

Use of Triplet (Phosphorescence) Organic Materials

- Power-conversion efficiency \equiv Light absorption \equiv Thickness of organic layer
 \notin Exciton diffusion length (10-30 nm @ organic)
- Exciton diffusion length = Mobility \times Lifetime
- Triplet (phosphorescence) organic materials have “long exciton lifetime $\geq \mu\text{s}$ ”
(fluorescence material: $\leq \text{nS}$)

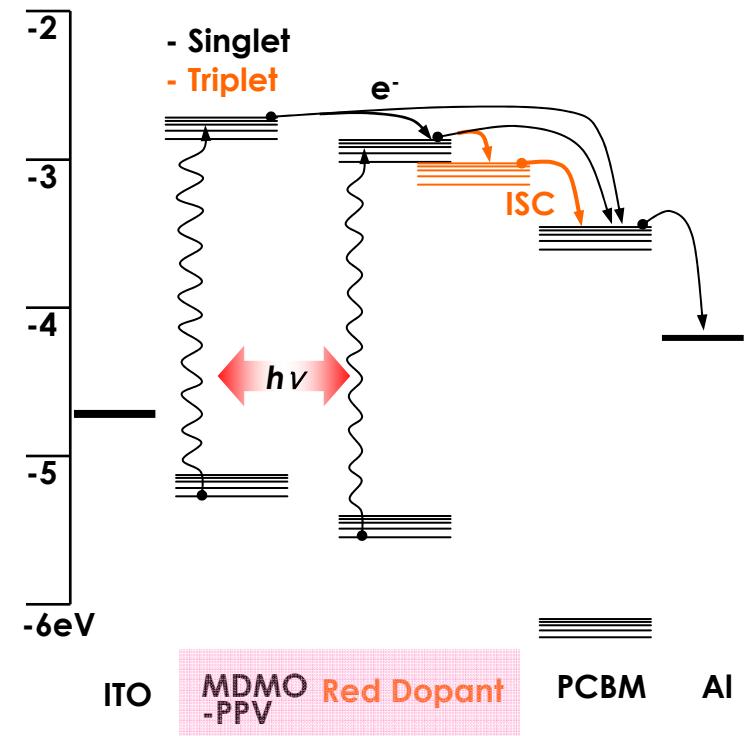


MDMO-PPV



PCBM

• Red Dopant

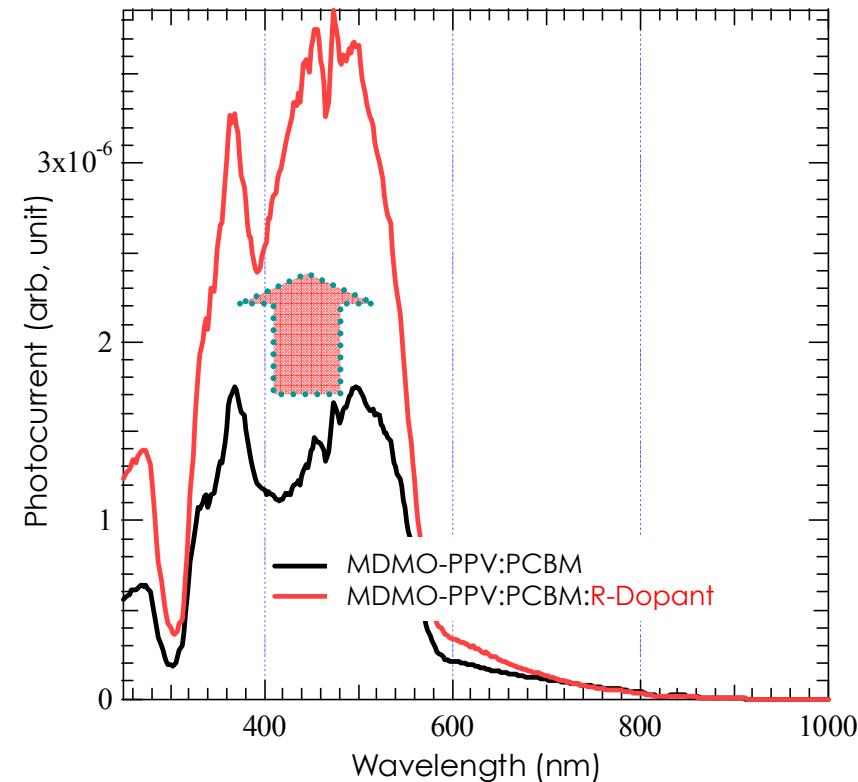
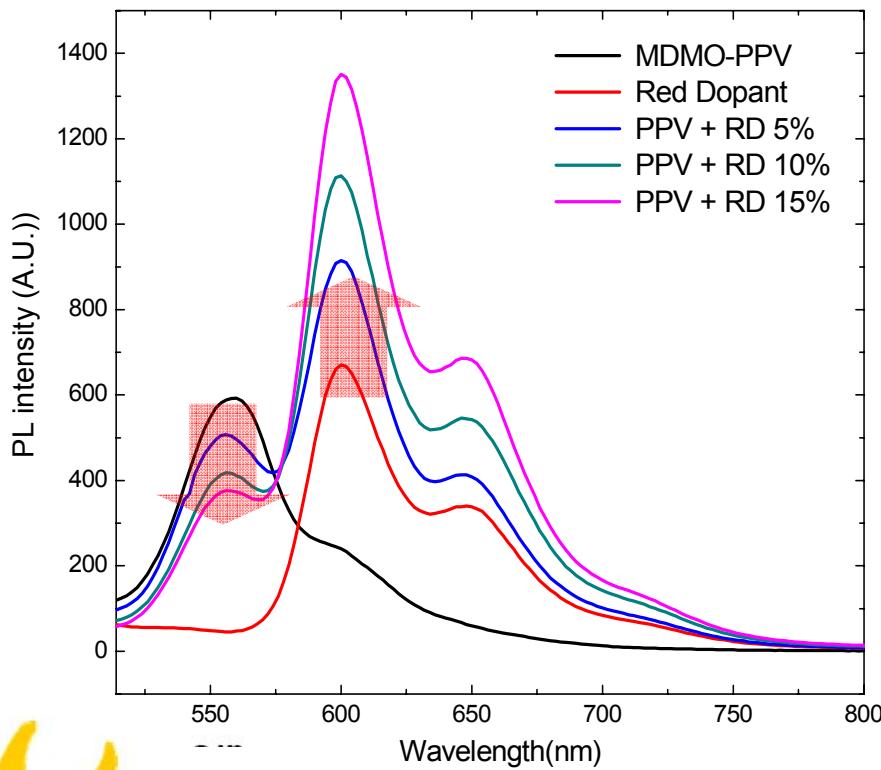




Approach # 2

Use of Triplet (Phosphorescence) Organic Materials

- Energy Transfer in PL measurement
(MDMO-PPV & Red Dopant)
- Photocurrent generation
(MDMO-PPV & Red Dopant)





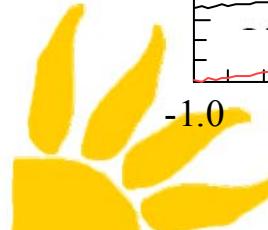
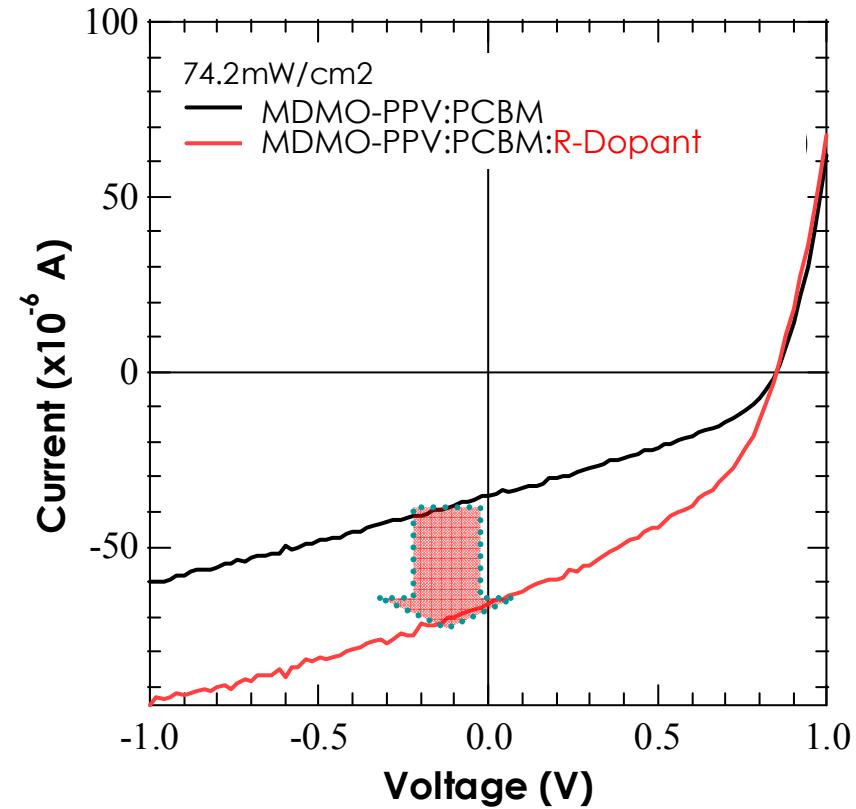
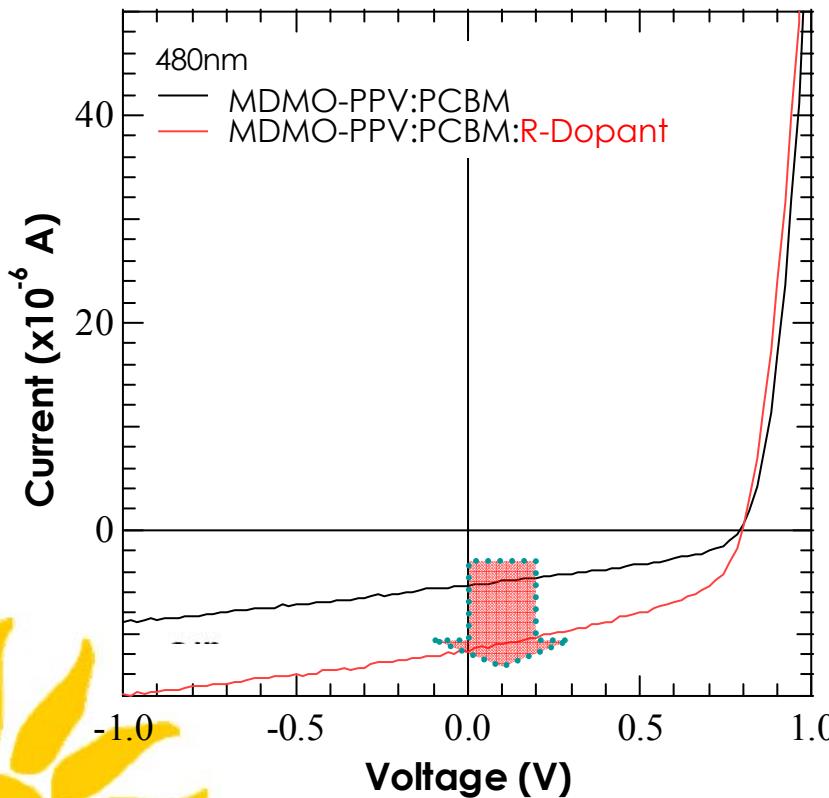
Approach # 2

Use of Triplet (Phosphorescence) Organic Materials

➤ Device Performances

ITO/ PEDT:PSS/ MDMO-PPV : PCBM/ LiF/ Al

ITO/ PEDT:PSS/ MDMO-PPV : PCBM : R-Dopant / LiF/ Al





Approach # 2

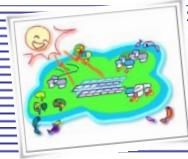
Use of Triplet (Phosphorescence) Organic Materials

	Voc (V)	Jsc(mA/cm ²)	FF	EFF(%)	IPCE(%)
ITO/ PEDT:PSS/ MDMO-PPV : PCBM/ LiF/ Al					
480nm(2.4mW/cm ²)	0.8	0.4	0.44	4.97	36.81
74.2mW/cm ²	0.85	2.62	0.42	1.28	
ITO/ PEDT:PSS/ MDMO-PPV : PCBM : R-Dopant / LiF/ Al					
480nm(2.4mW/cm ²)	0.8	0.64	0.46	8.25	58.68
74.2mW/cm ²	0.85	3.64	0.41	1.72	



- - -





More Questions or Discussion ?

Welcome !!

Chonbuk National University

POWER 전북대학교 아름다운 학교



Thank you !!

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