Molecular and Organic Excitonics Lab
Solar Research Projects

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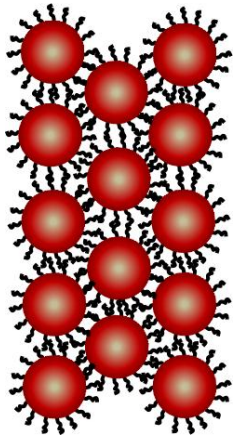
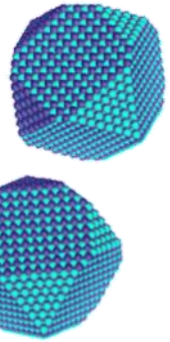
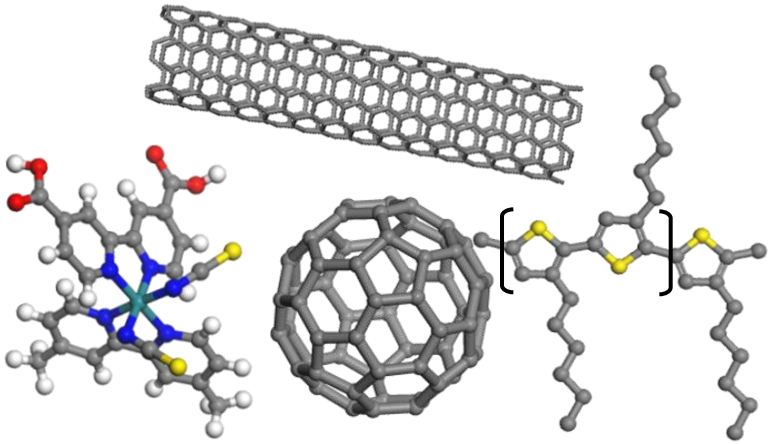
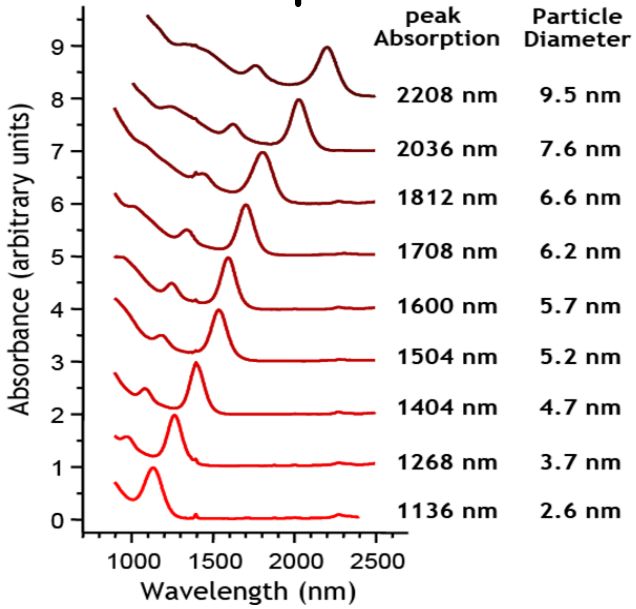
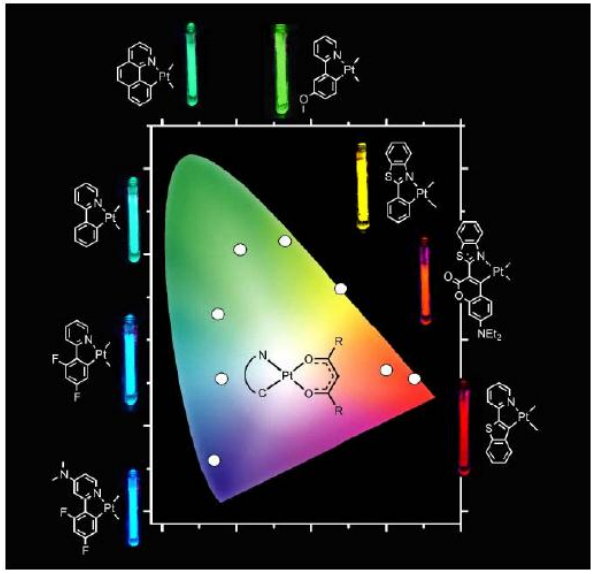
Nanostructured Materials



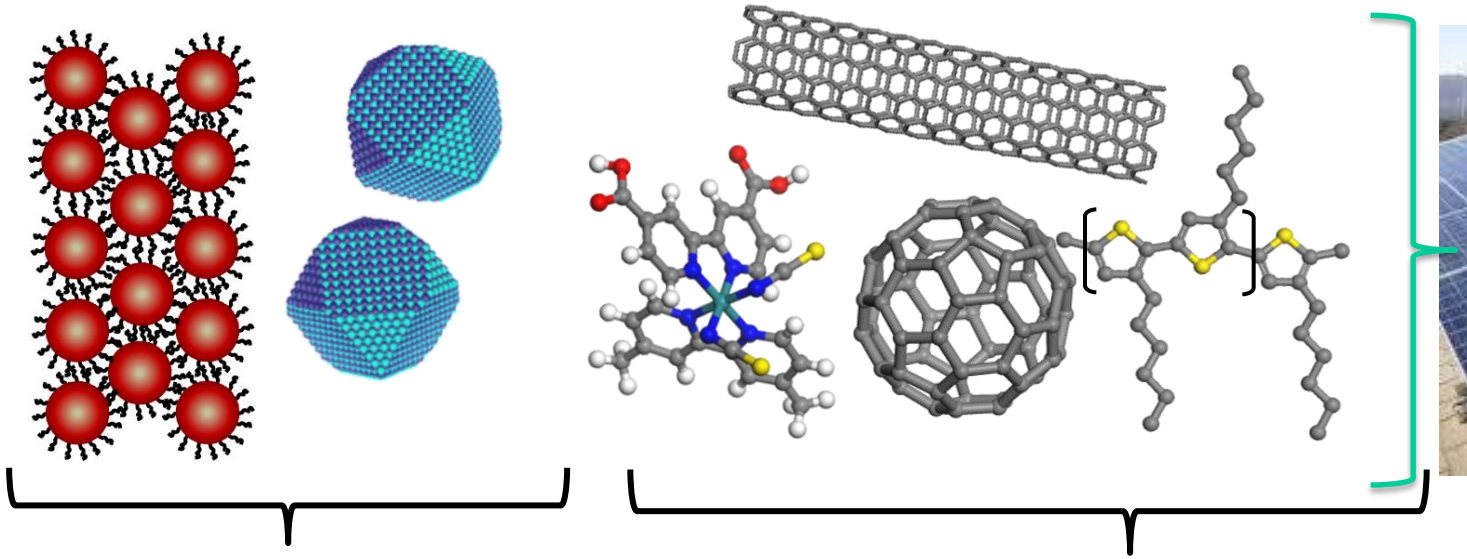








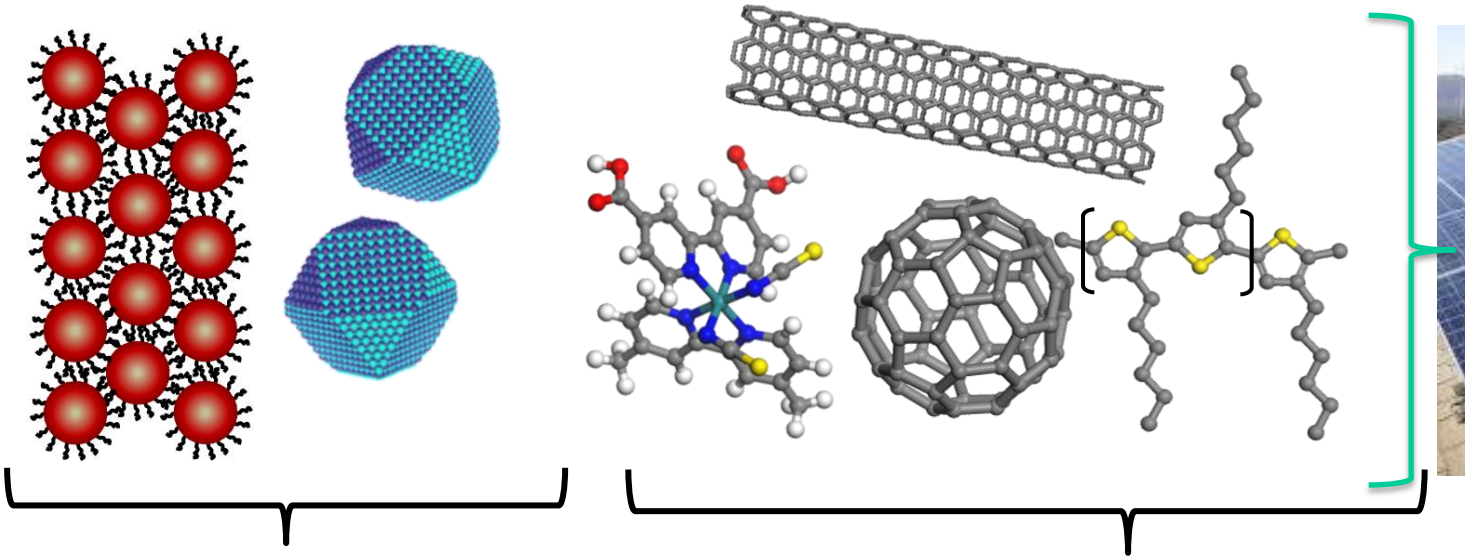
Nanostructured Materials



Our goal New Routes to Low Cost Solar Energy and Energy Efficient Electronics with unique functionality

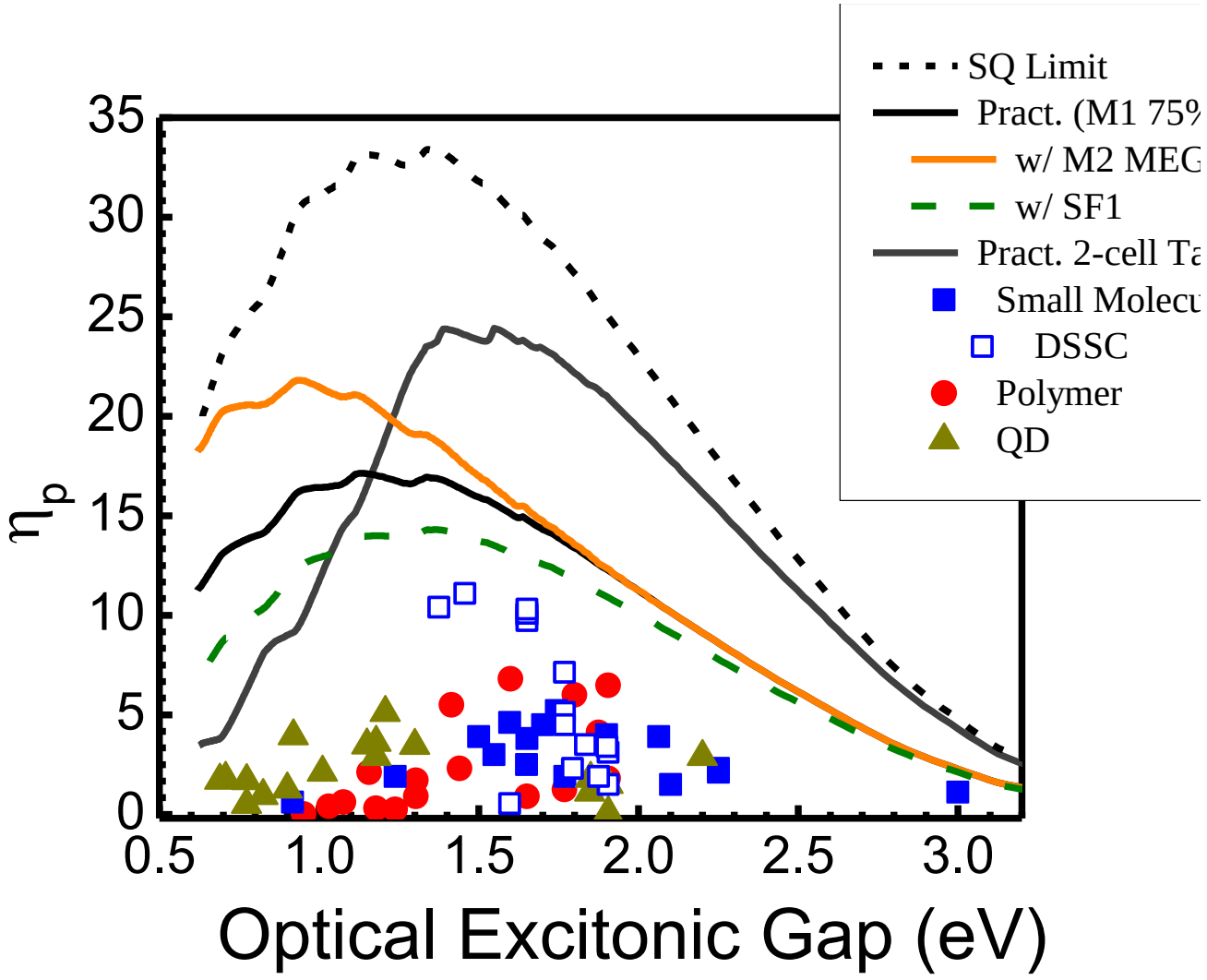
Our strategy is to exploit oriented, crystalline, and nanostructured excitonic materials through organic-organic, organic-inorganic interactions while studying relationships between structure and photophysical properties

Nanostructured Materials



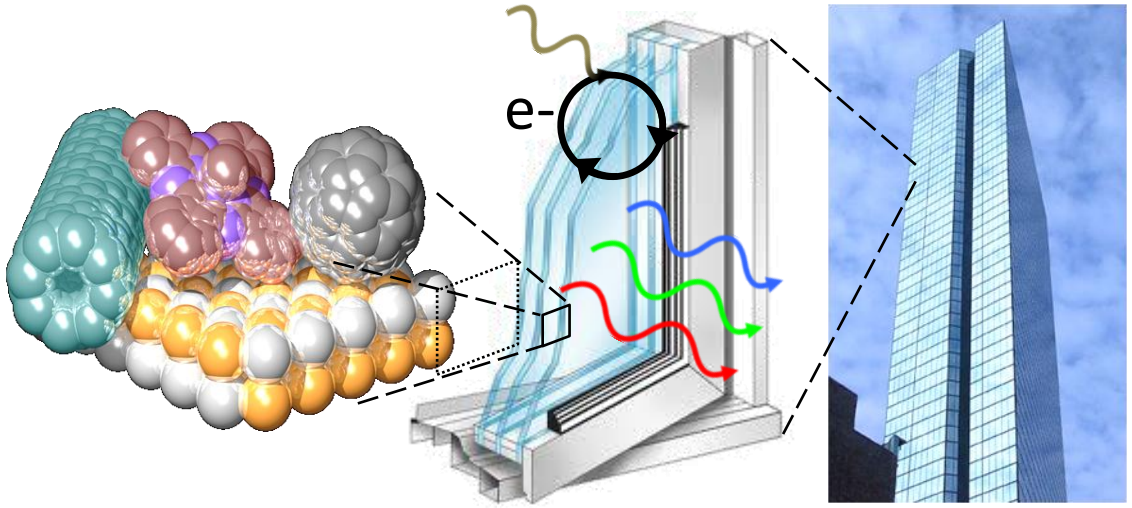
- Tunable Band Gaps!,
- Low Cost, Lightweight, Flexible
- Excitons = Unique Properties and Opportunities!

Practical Efficiency Limits



Lunt et al *Adv Mat*, 23, 5712.

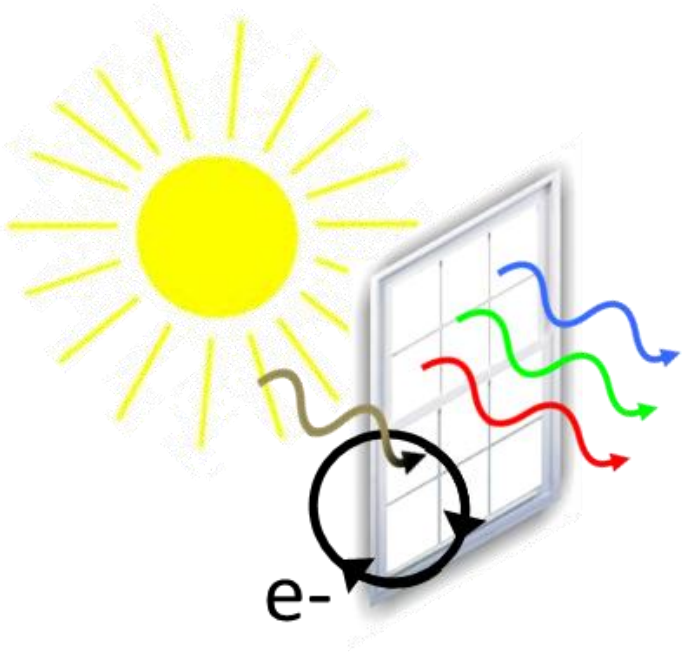
Unique Opportunities for Excitonic PVs

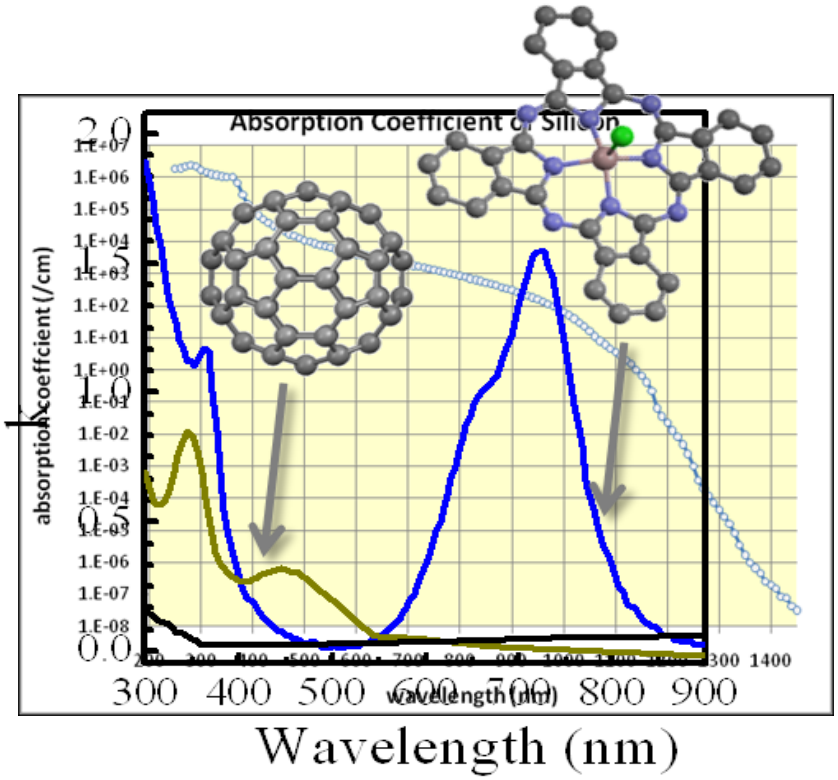


Transparent Solar Cells



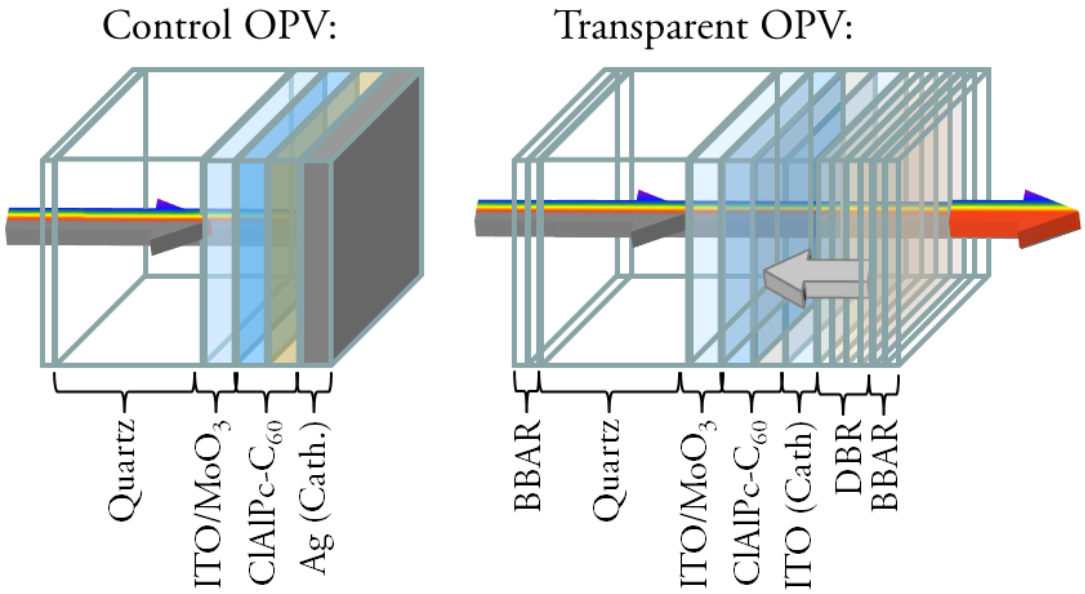


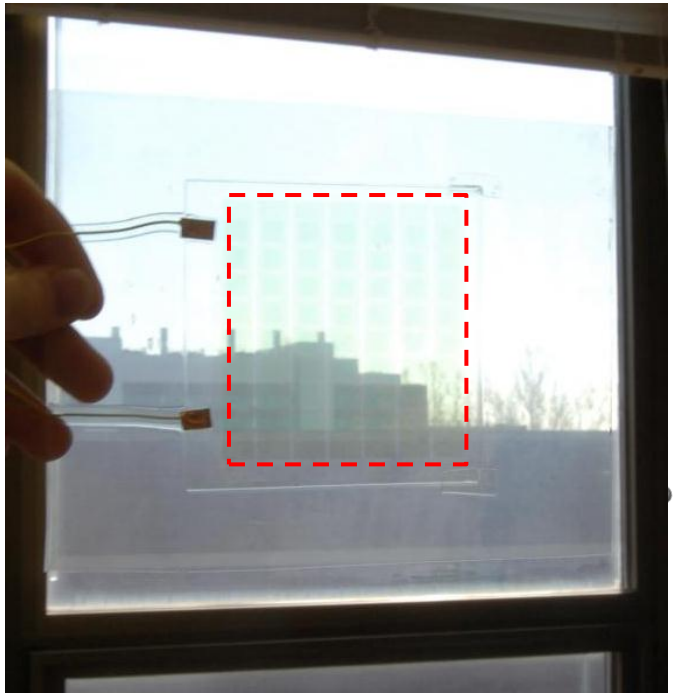




Wavelength (nm)

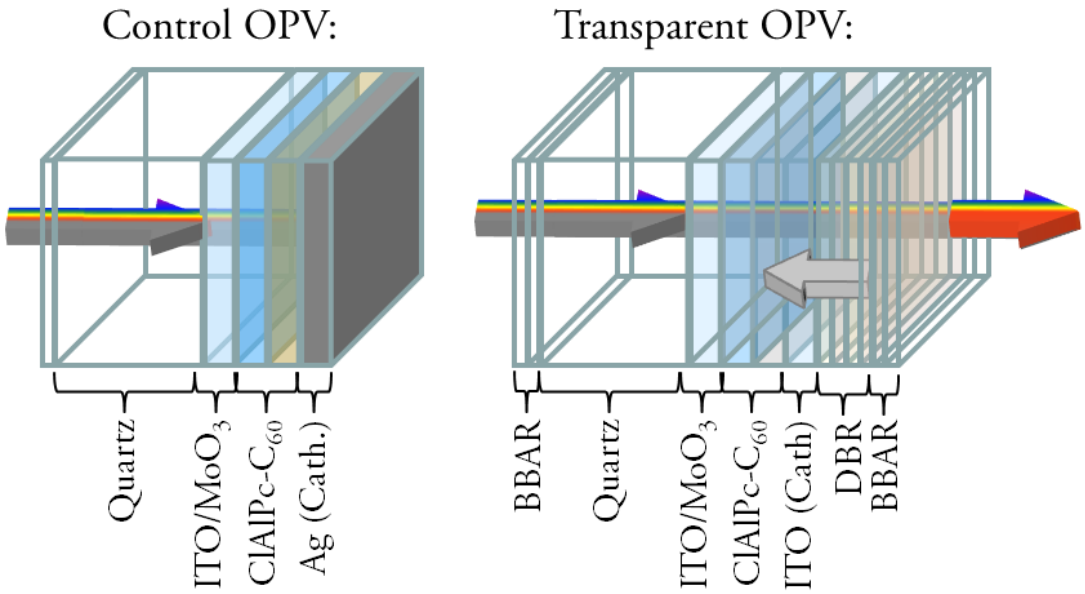
Transparent Solar Cells

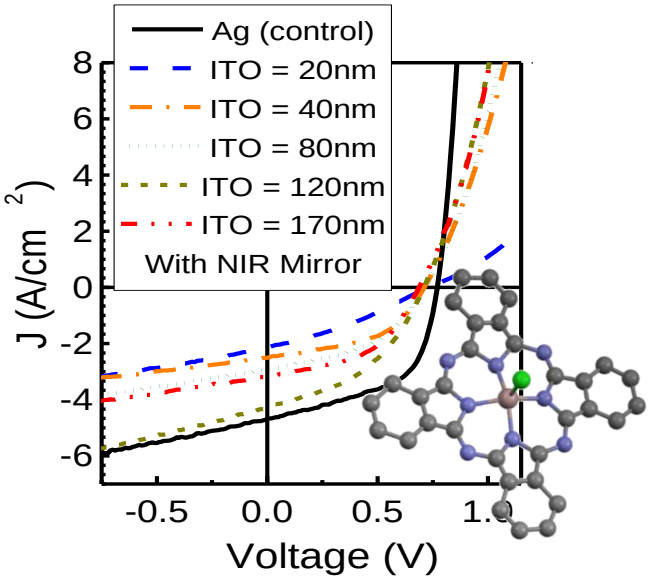




- 2/3 Solar Flux in NIR/IR → Single Junction Limit (20%), 10-cell Tandem (33%)
- Use Excitonic Materials to optimize Transparency and Efficiency
- Optimize Optical Interference from Cathode/Anode – Transparent NIR Mirror

Transparent Solar Cells





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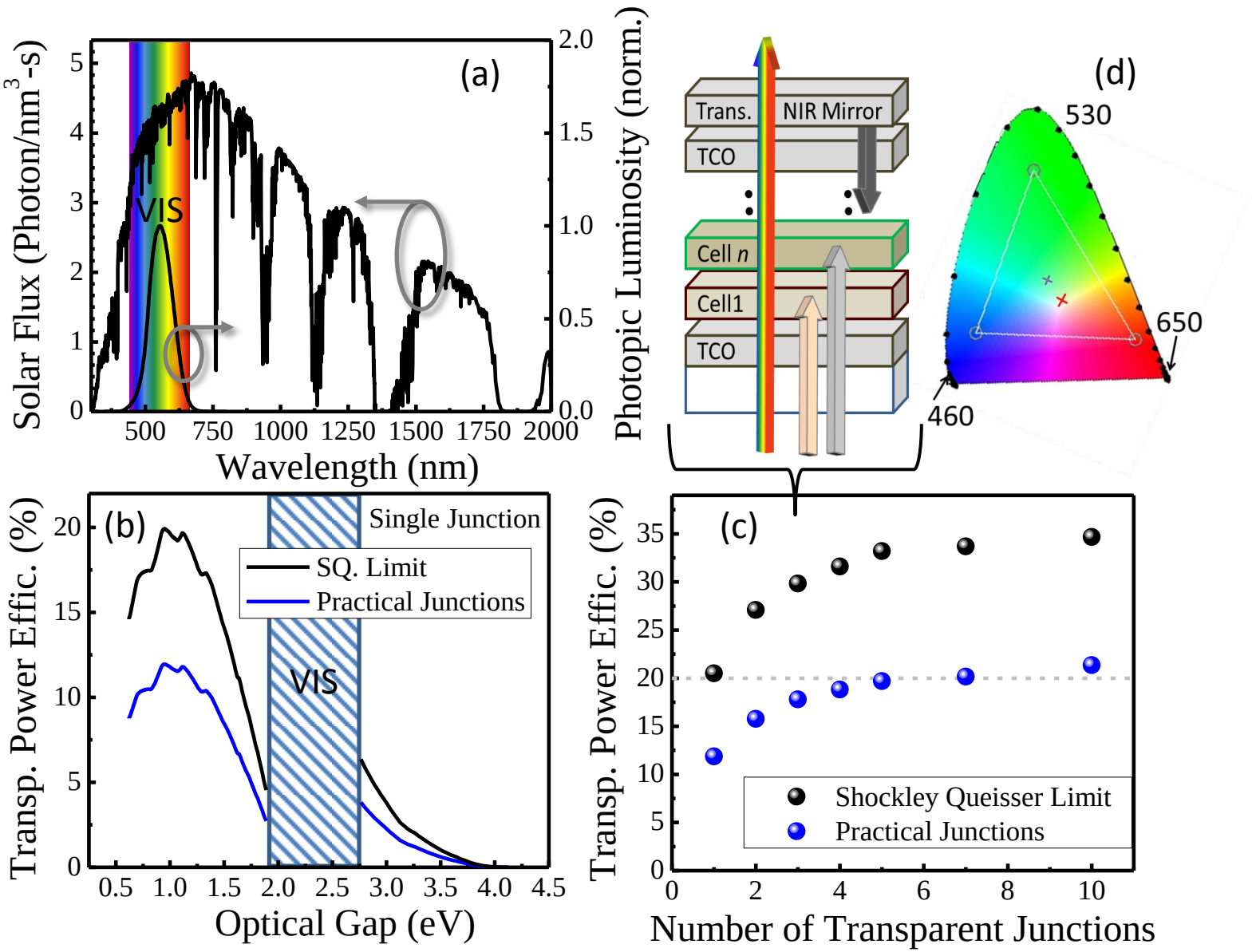
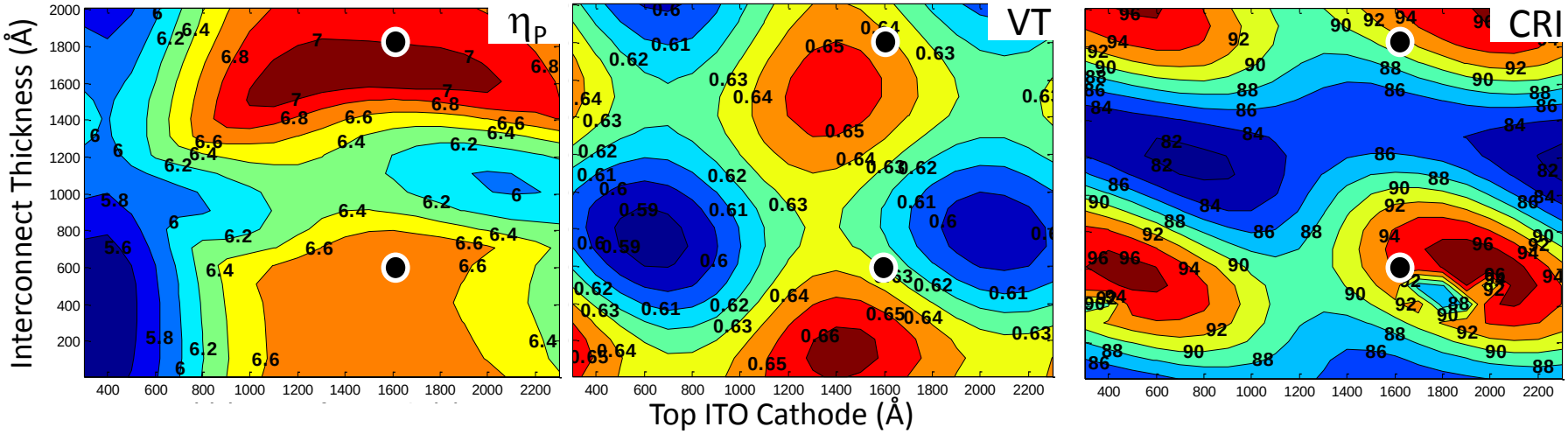
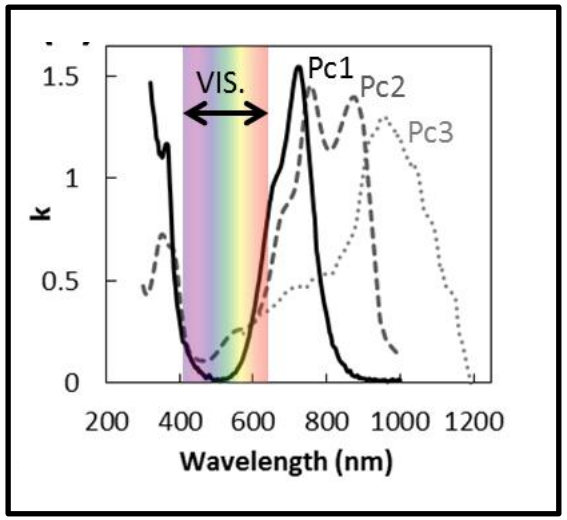
Limits


(a)
Solar Flux (Photon/nm^3-s)
Photopic Luminosity (norm.)
VIS
Wavelength (nm)
(b)
Single Junction
SQ. Limit
Practical Junctions
VIS
Transp. Power Effic. (%)
Optical Gap (eV)
Trans.
NIR Mirror
TCO
Cell n
Cell1
TCO
(c)
Shockley Queisser Limit
Practical Junctions
Transp. Power Effic. (%)
Number of Transparent Junctions
(d)
530
650
460

Efficiency Limits with MJ-TOPV

- Simulated Combination of Already Demonstrated Subcells
- Complex Landscape for MJ!



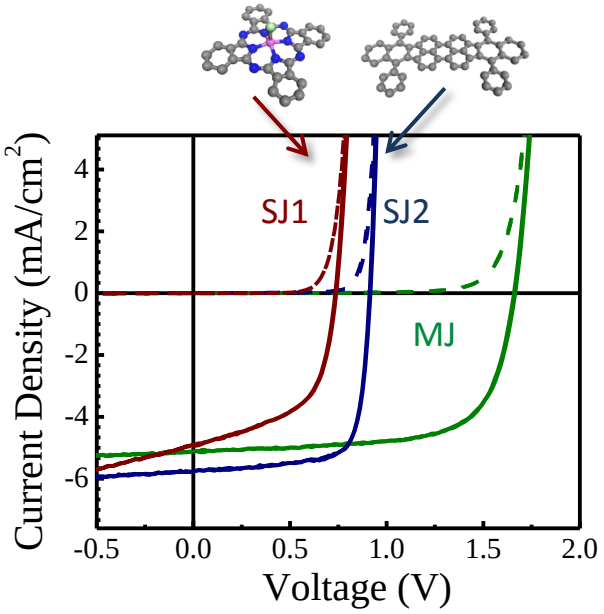


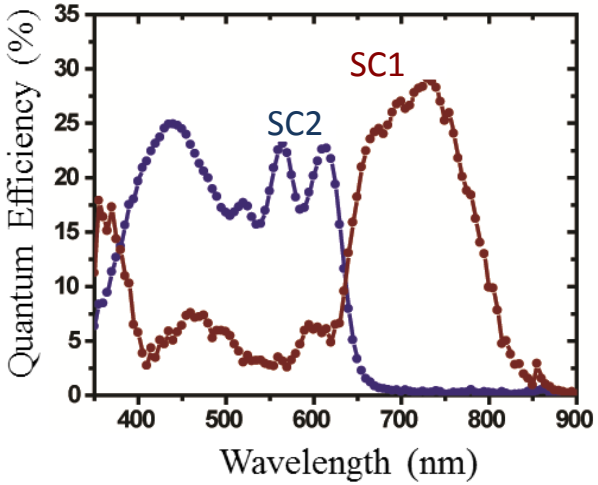
η_P = 7.0%
VT = 64%
CRI = 92

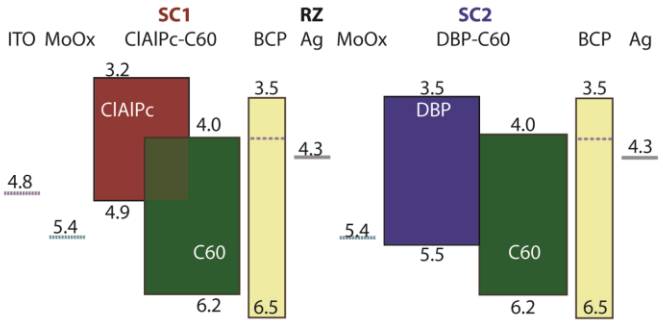
Only optimized for 2/10 Variables

Additional MOE Lab Projects Related to Energy and PVs

Reducing Thermal Losses: TOPVs in Opaque Multijunctions







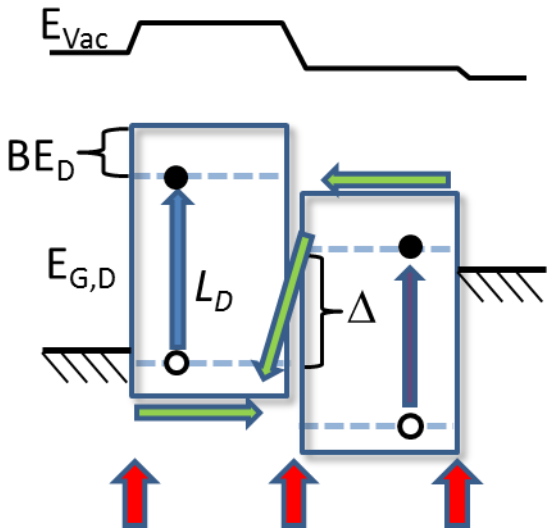
Transparent Subcell Visible Subcell

	Jsc (mA/cm^2)	Voc (V)	FF	PCE (%)
SJ1: ClAlPc-C60 (optimal)	7.1	0.78	0.51	2.8 ±0.1
SJ2: DBP-C60 (optimal)	6.2	0.92	0.70	4.0 ±0.1
SJ1: ClAlPc-C60 (subcell)	4.6	0.73	0.56	1.9 ±0.1
SJ2: DBP-C60 (subcell)	5.5	0.91	0.73	3.7 ±0.2
MJ: Multi-junction	4.9	1.65	0.68	5.6 ±0.2

Push EQE to 60% → > 10% efficiency!

Rowehl et al. 2012 (Accepted)

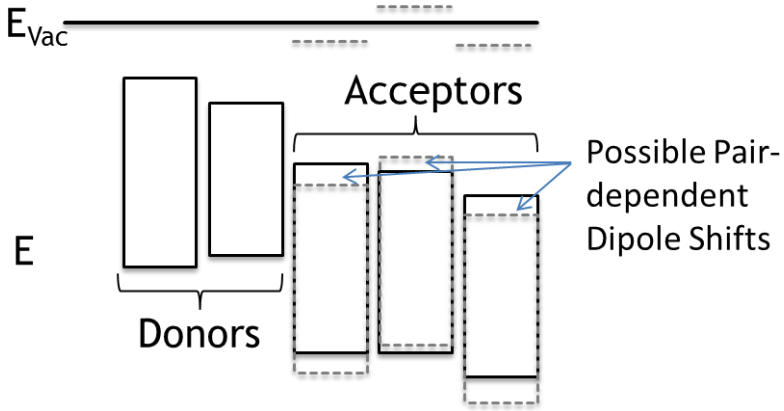
Factors that Limit Photovoltage

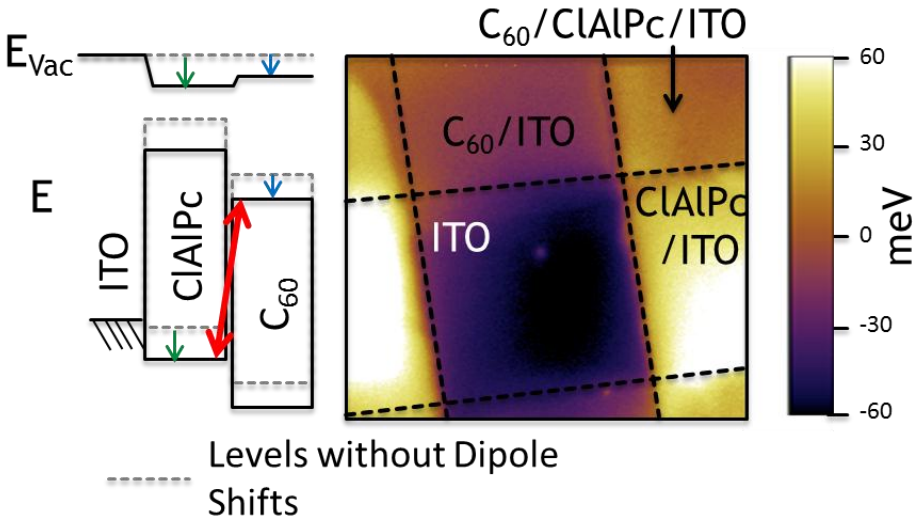


Key interfaces for Voltage

$\uparrow \Delta \uparrow V_{OC} \downarrow J_{SC}$

1) Where is the optimum Δ?
2) Understand Dipole Shift Interac. (pairing dependent!)

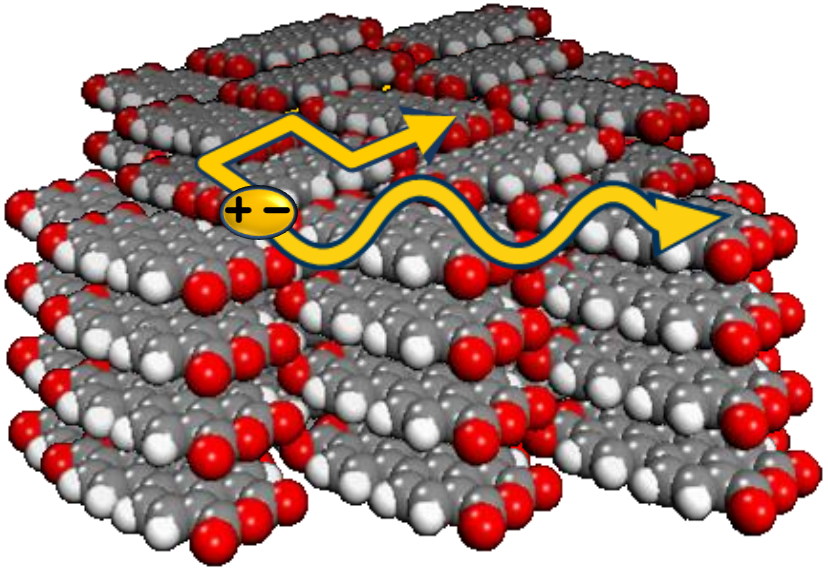


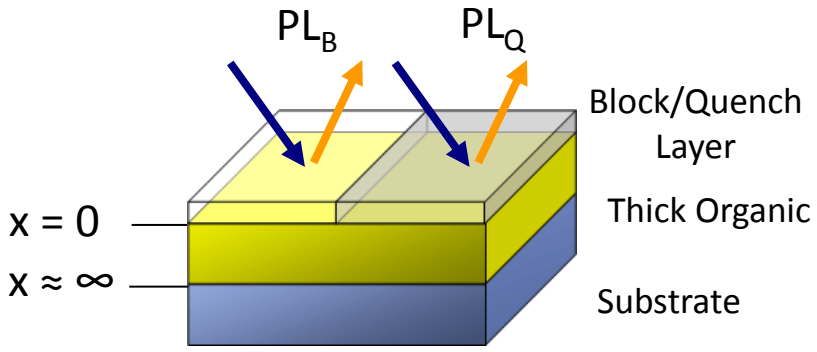


Lunt et al. In prep

Current Generation: Exciton Diffusion

Key Energy Carrier in OPV, OLED, Exciton Transistors, etc.





$$\frac{\partial n}{dt} = D\nabla^2 n - \frac{n}{\tau} + I_0 \alpha' e^{-\alpha' x} = 0.$$

Explore diffusion Mechanisms as function of:

- Temperature
- Crystalline Ordering (amorphous, crystalline, single crystal)
- Crystal Orientation, Packing Configuration, Molecular Substitutions