

Influence of Electrodes, Light, and Air on Organic Photovoltaic Stability and Various Device Protection Strategies

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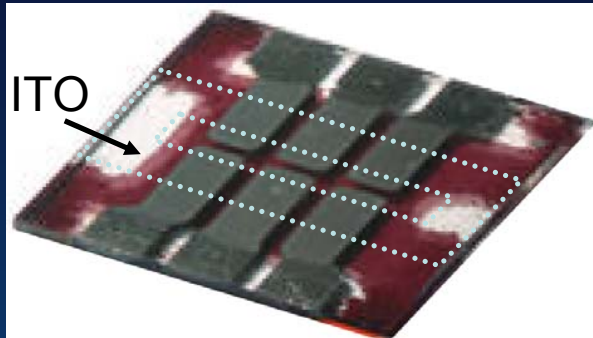
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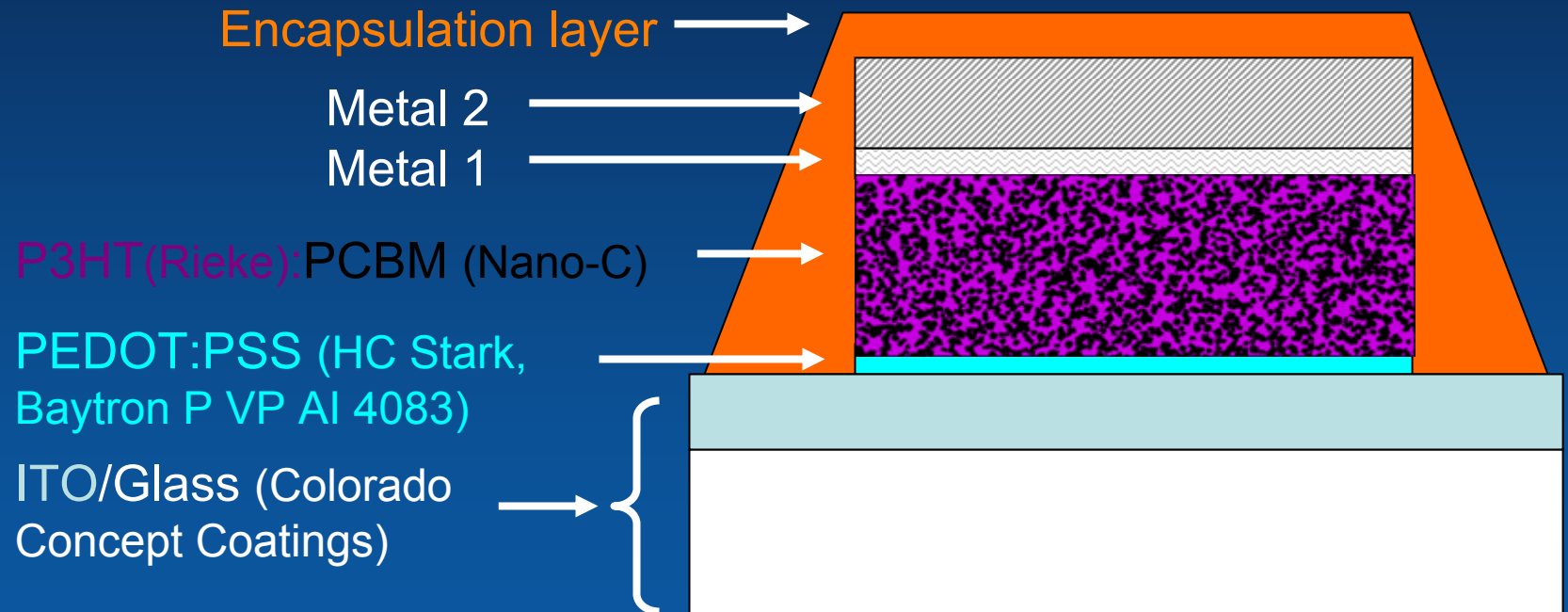
Introduction

- OPV model system
- Electrode type
- Light vs. dark stability in inert atmosphere
- Light vs. dark: active layer or metal/organic interface
- Light degradation mitigation strategies in air

Prototypical Sample

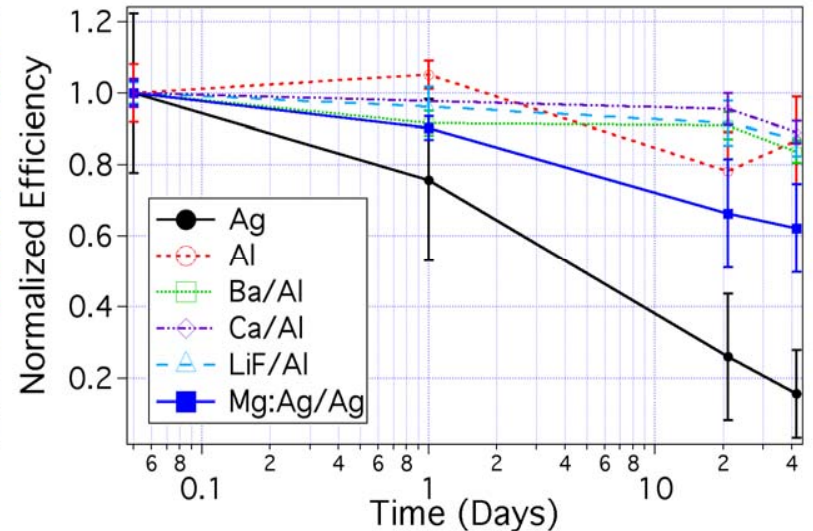
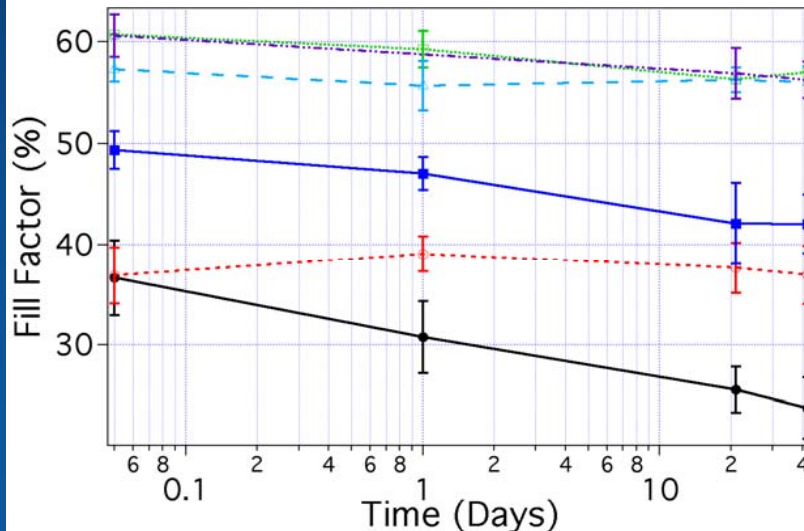
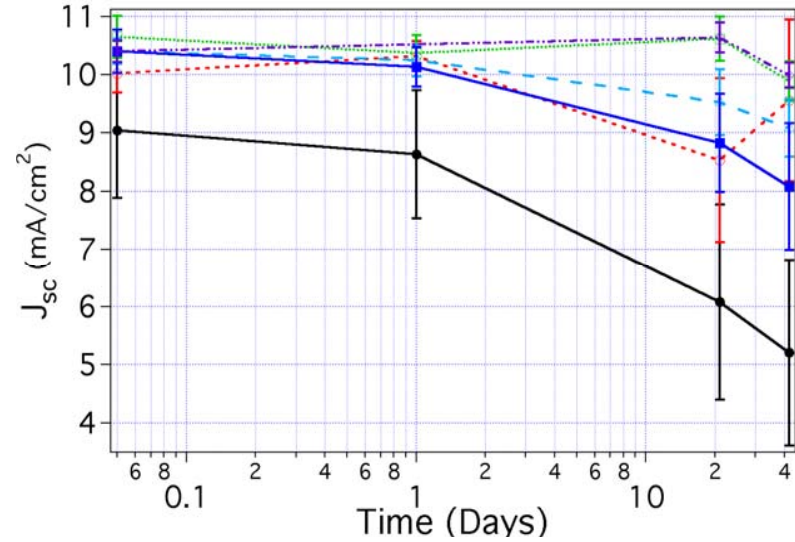
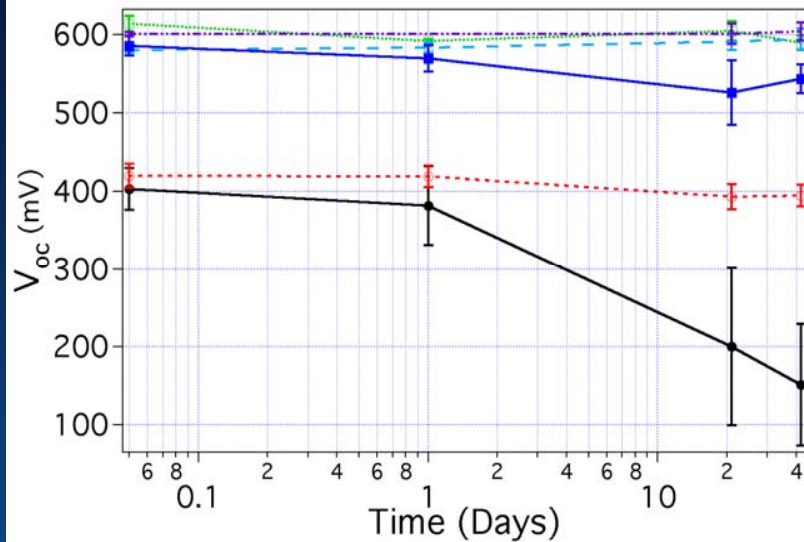


The active layer is P3HT:PCBM 1:1 wt ratio, [50 mg/mL] solvent annealed from 1,2-dichlorobenzene¹



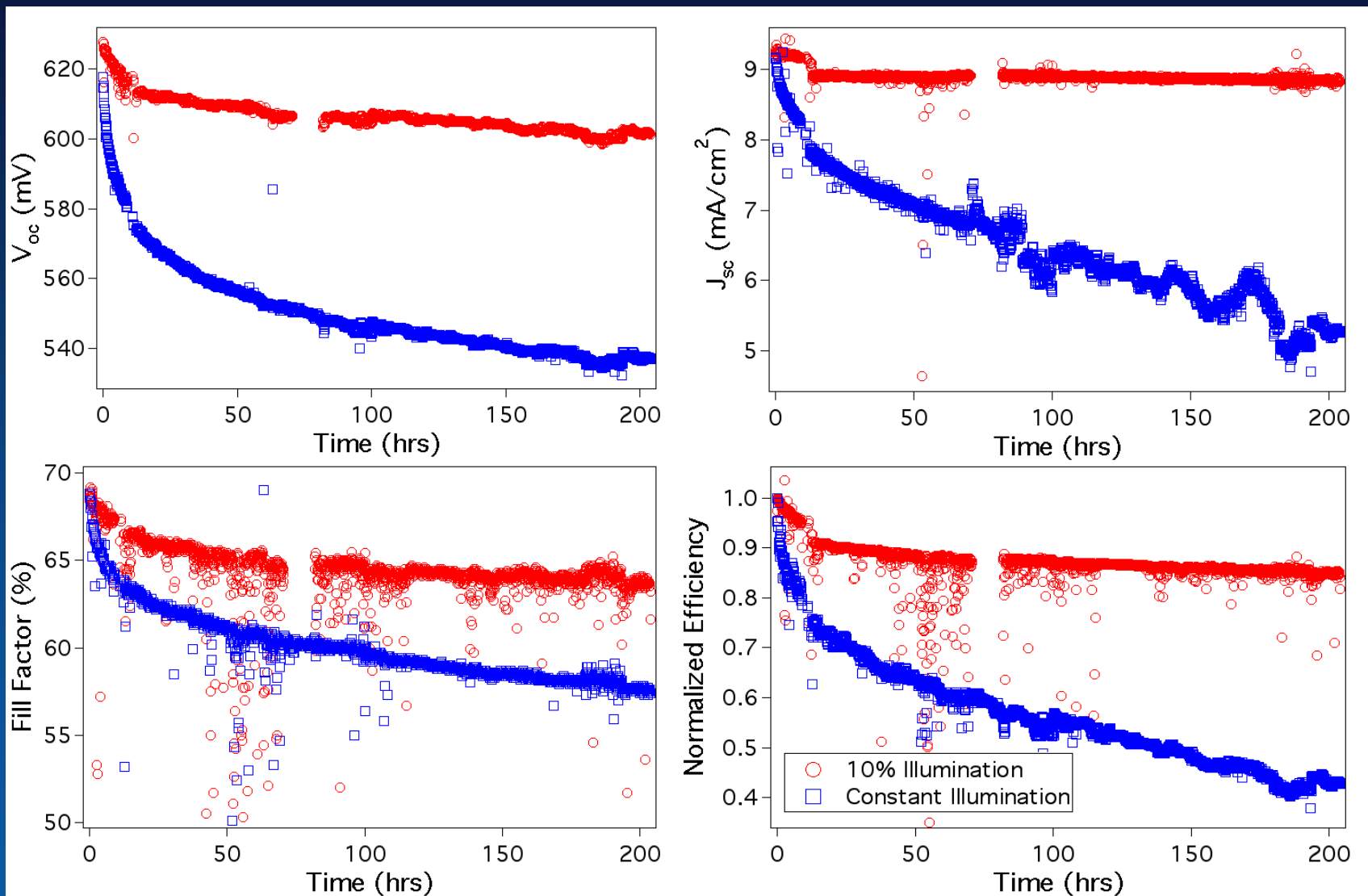
1. G. Li, *et al.*, Nat. Mater. 4 (2005) 864.

Electrode Type Study (Six week shelf life study)

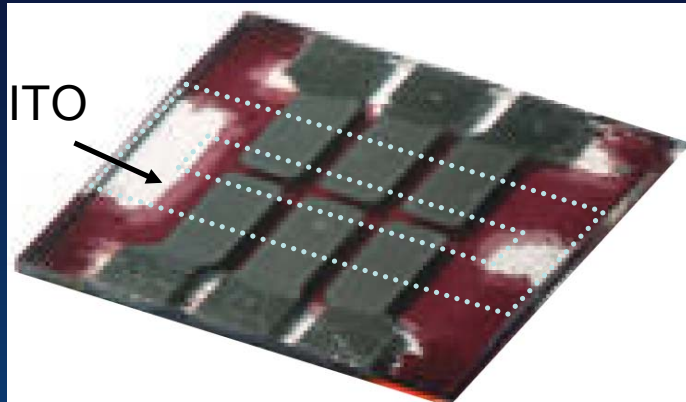


1. M.O. Reese, *et al.*, Appl. Phys. Lett. 92 (2008) 053307.
2. M.O. Reese, *et al.*, Sol. Energy Mater. Sol. Cells 92 (2008) 746.

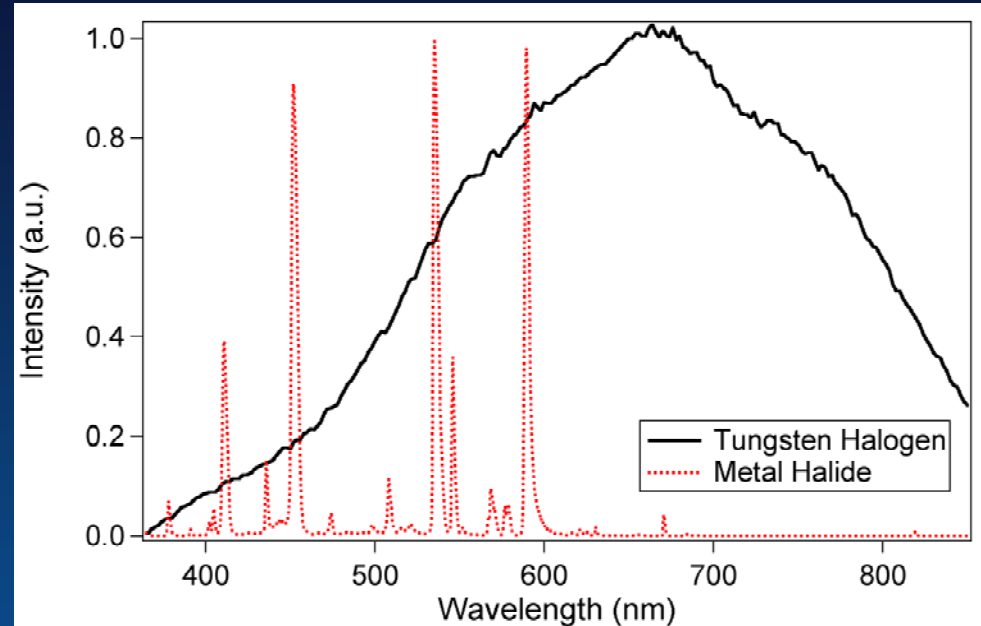
Light vs. Dark Stability in Inert Atmosphere



Delayed Contacts - Metal/Organic Interface



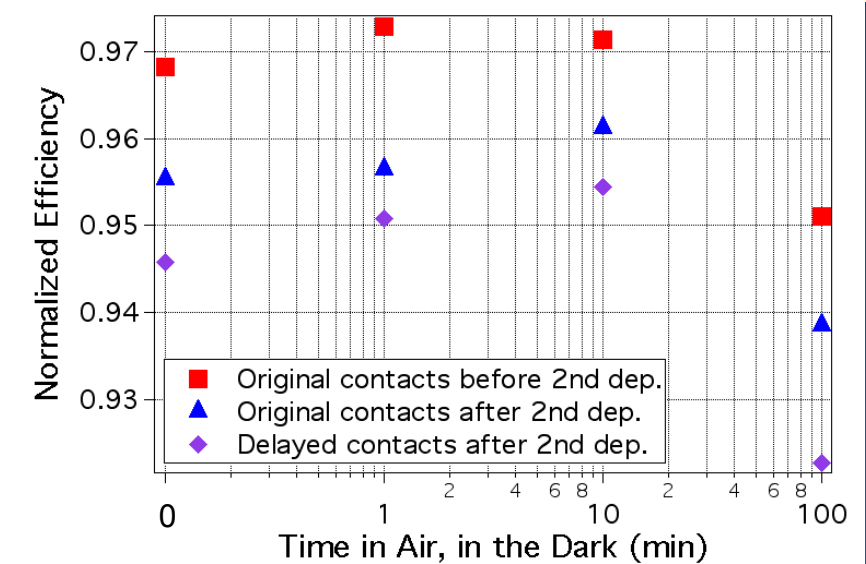
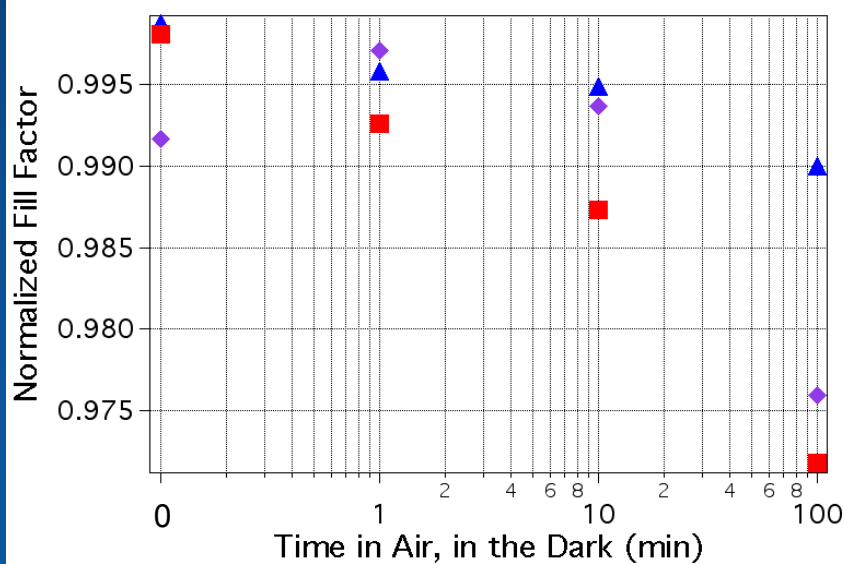
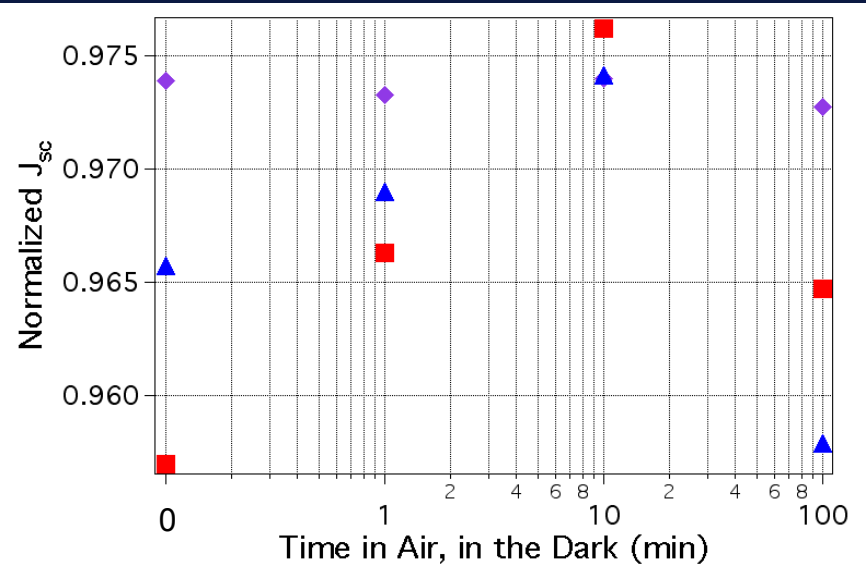
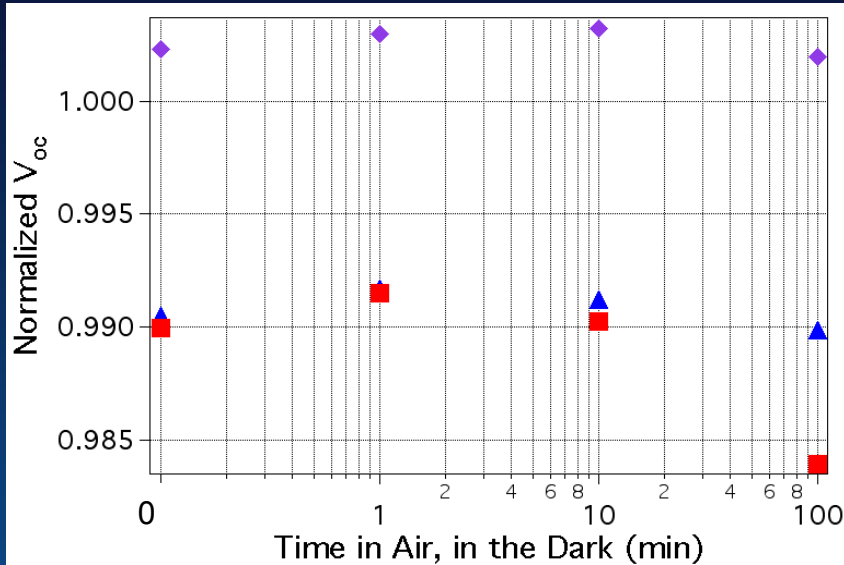
- Ambient → Metal Halide
- Glovebox → Tungsten Halogen (EXT)
- Devices illuminated for 10 days before delayed contacts



Contacts	Glovebox 10% Illumination (#1)			Glovebox Constant Illumination (#2)			Air Constant Illumination (#3)	
	Original ($t=t_0$)	Original ($t=t_f$)	Delayed ($t=t_f$)	Original ($t=t_0$)	Original ($t=t_f$)	Delayed ($t=t_f$)	Original ($t=t_f$)	Delayed ($t=t_f$)
V_{oc} (mV)	624	601	614	615	559	591	564	278
J_{sc} (mA/cm ²)	9.25	9.18	9.20	9.48	4.95	8.26	6.76	9.3×10^{-5}
FF (%)	68.3	63.6	65.2	68.2	53.2	57.0	58.3	29.0
Efficiency (%)	3.95	3.51	3.68	3.97	1.47	2.78	2.22	7.5×10^{-6}

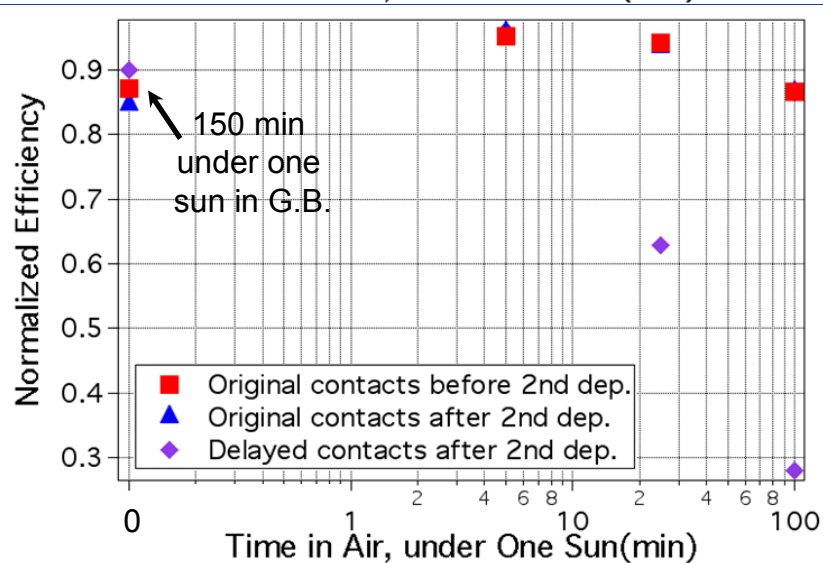
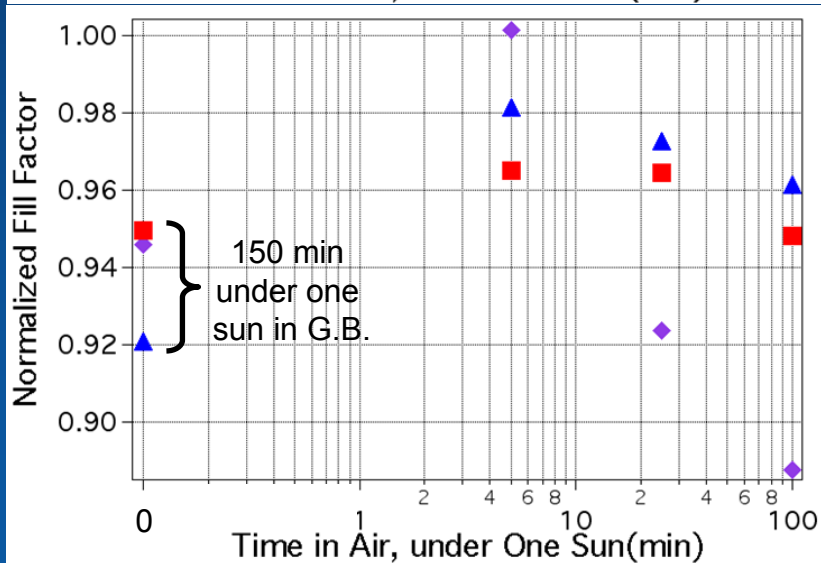
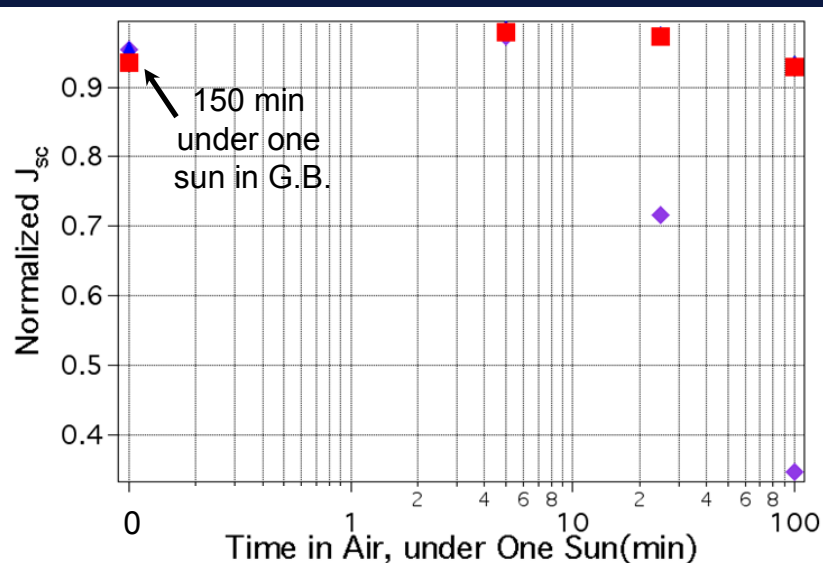
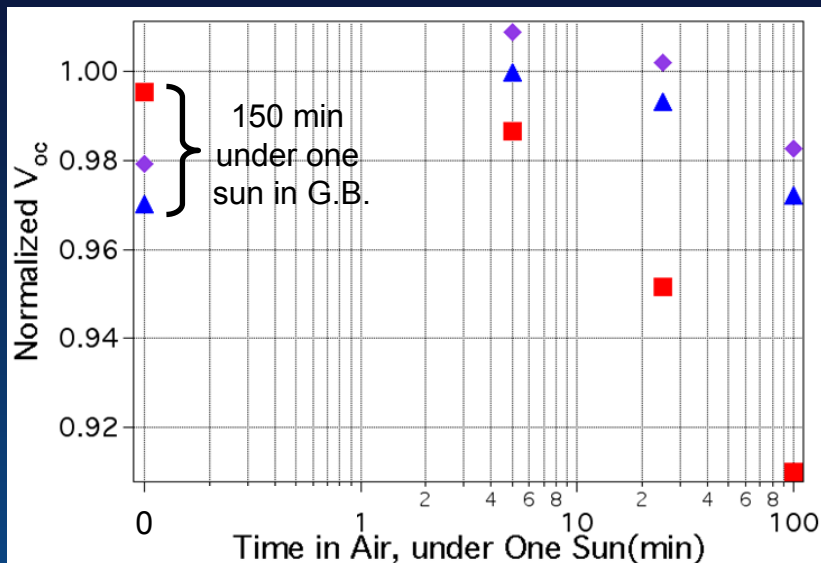
Delayed Contacts #2

What timescale (in the dark)?



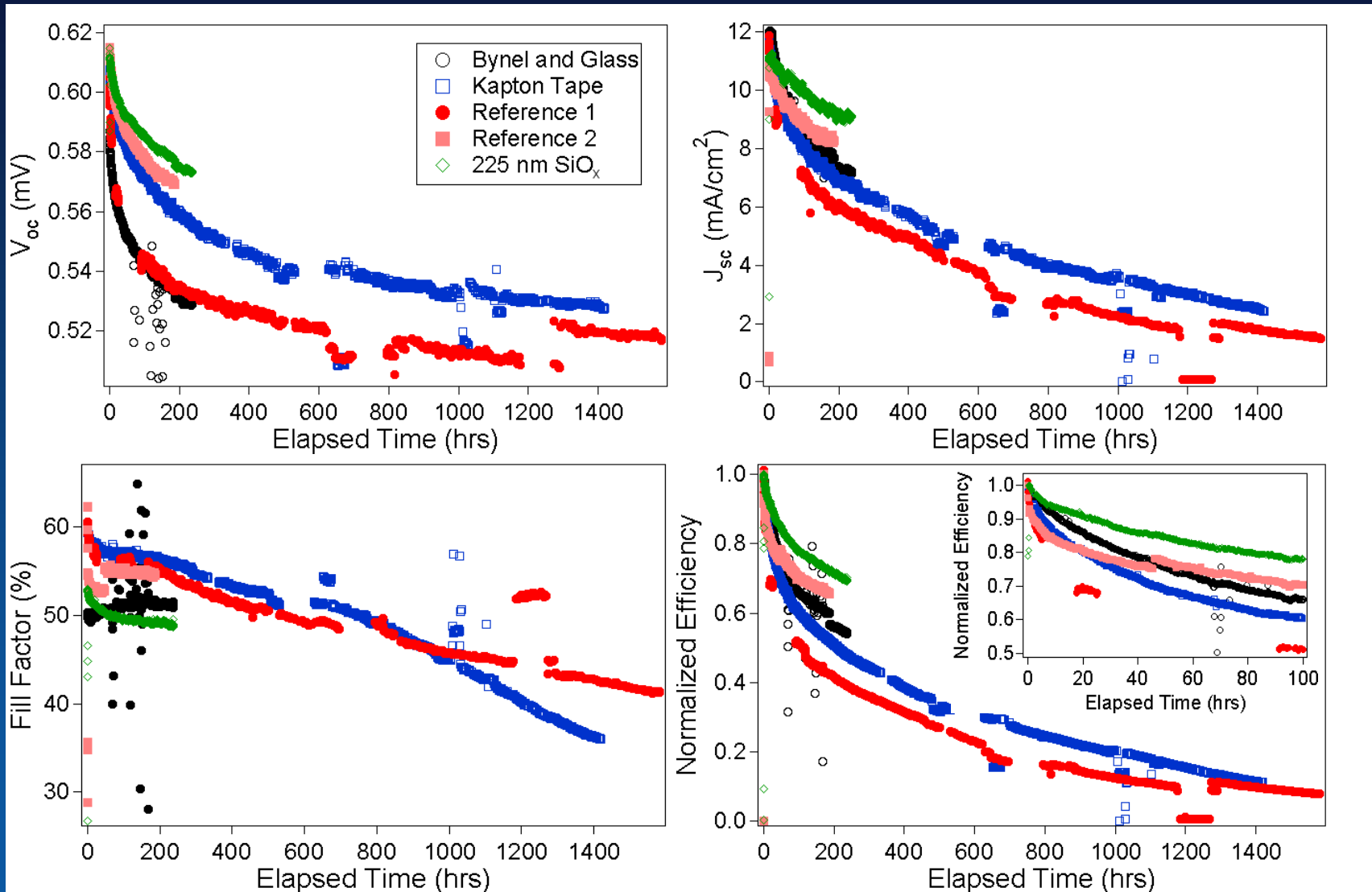
Delayed Contacts #3

What timescale (under one sun illumination)?



- Original contacts before 2nd dep.
- ▲ Original contacts after 2nd dep.
- ◆ Delayed contacts after 2nd dep.

Ambient Tests



Conclusions

- Ag electrodes → inherently unstable
- Ca/Al electrodes → high eff. + stability
- Photoactivated/temperature instability in inert atmosphere
- Metal/organic interface may be a significant contributor to degradation (photoactivated?)
- Surprising robustness of devices in air and dark
- Organic surface degrades in tens of minutes under one sun illumination
- Short timescale modulated by encapsulation