Research Highlights
Flexible Electronics and Photovoltaics (FEP)

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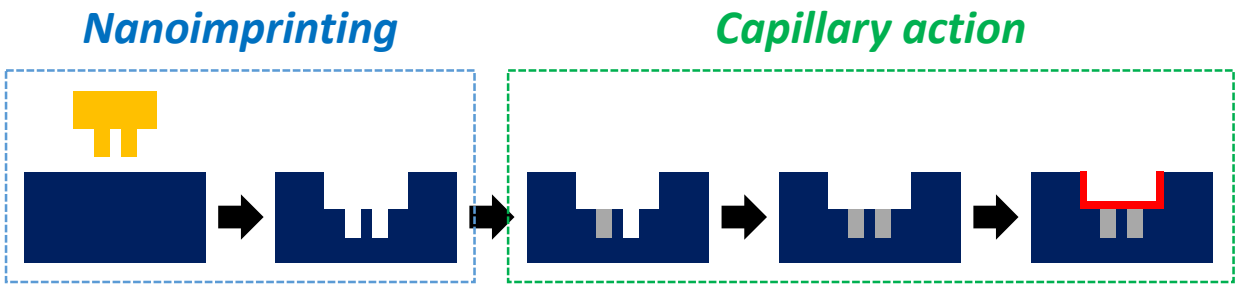
Investigator	Department	Expertise
Russell J. Holmes	CEMS	*Thin films, LEDs, solar cells*
David Blank	CHEM	*Ultrafast spectroscopy*
Chris Douglas	CHEM	*Molecular synthesis*
C. Daniel Frisbie	CEMS	*TFTs and printed electronics*
P. Paul Ruden	ECE	*Device modeling, transport theory*

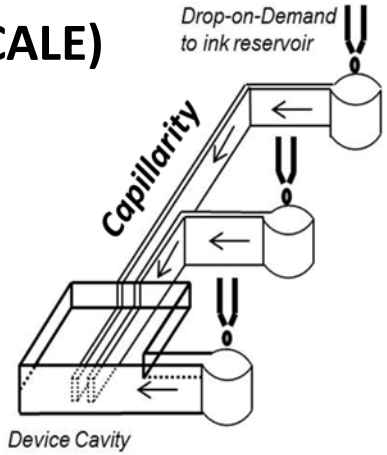
**Program Leader*

Interested in the design of materials, device architectures, and processes for the realization of flexible electronics and optoelectronics based on organic and hybrid organic-inorganic materials

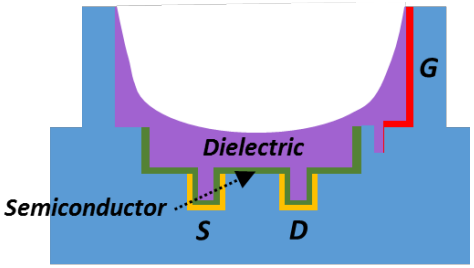
Self-aligned Strategy for Printed Electronics

Self-aligned **C**apillarity-**A**ssisted **L**ithography for **E**lectronics **(SCALE)**

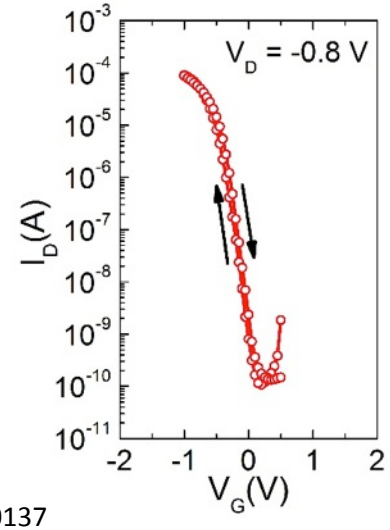




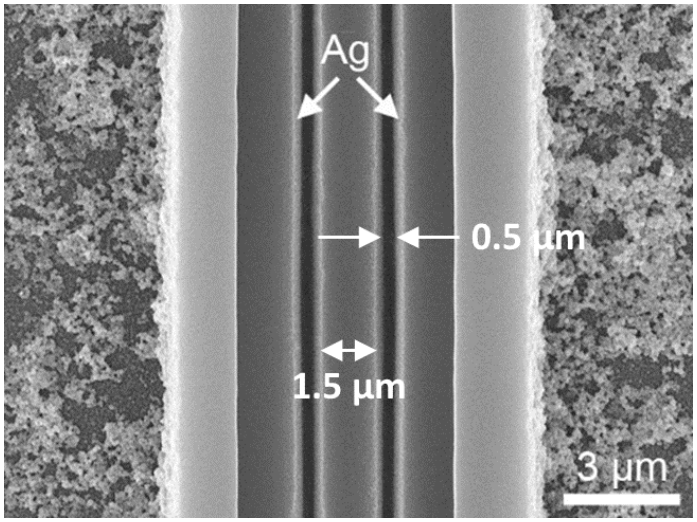
✓ **Self-aligned fabrication**
(2015 IPRIME meeting)



Thin-film transistor



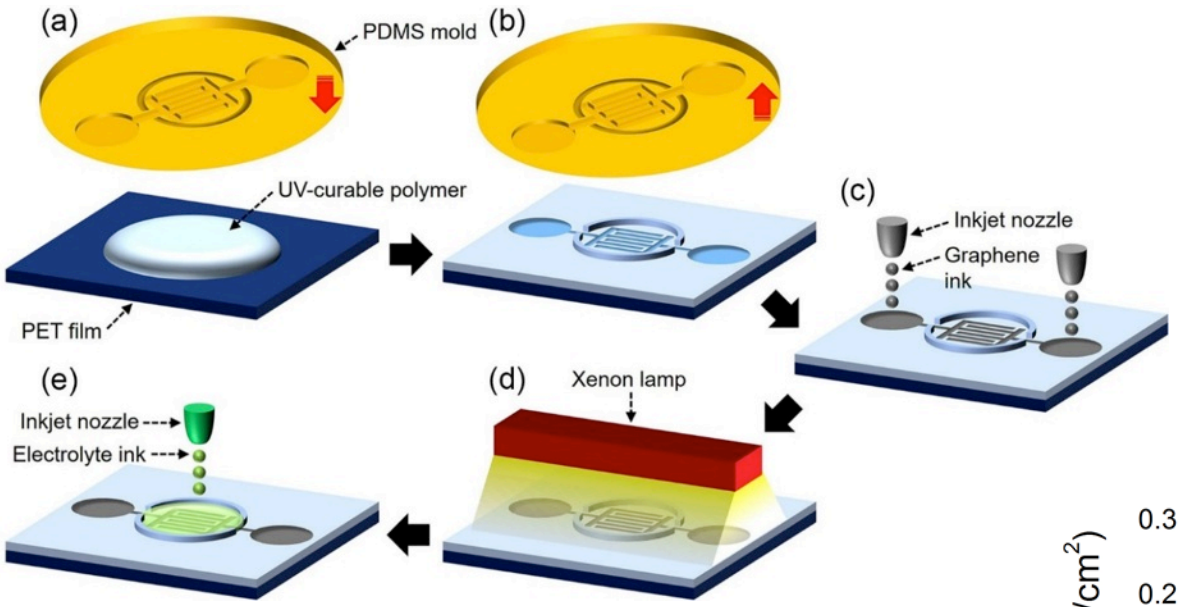
✓ **High-resolution**
(2016 IPRIME meeting)

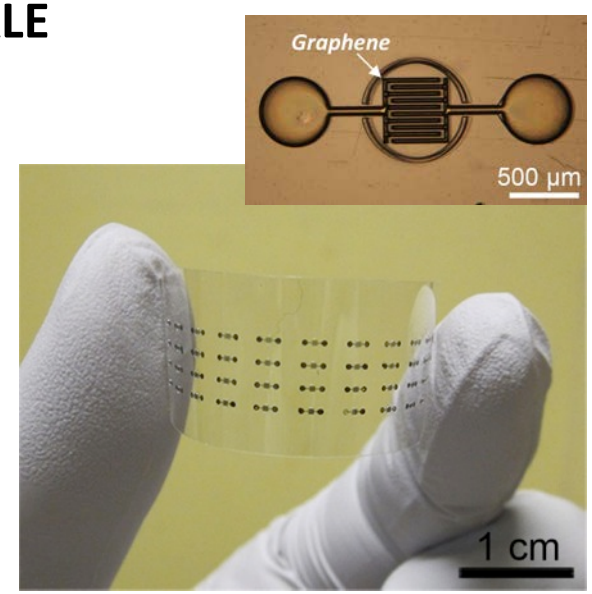


Frisbie et al., *Adv. Electron. Mater.* **2015,** 1, 1500137
Frisbie et al., *Adv. Electron. Mater.* **2016,** *2,* 1600293

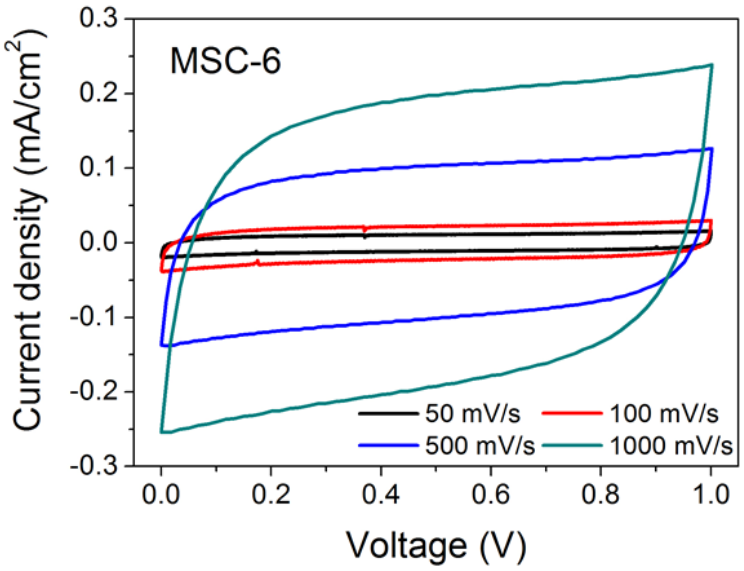
Self-aligned Strategy for Printed Electronics

Fabrication of graphene micro-supercapacitors by SCALE





- Active footprint: < 1 mm^2
- Minimum feature size: 20 µm
- Areal capacitance: 268 $\mu F/cm^2$
- Fabrication yield: 100% (44/44)



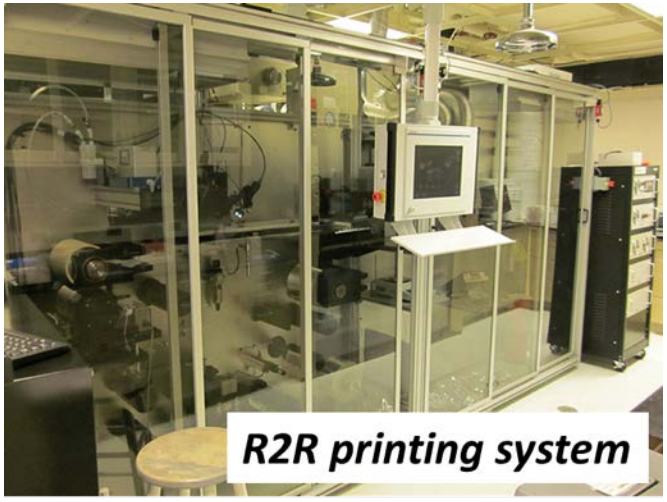
Frisbie et al., *Adv. Energy Mater.* **2017,** in press.

Roll-to-Roll Production

Web

Imprinted
(channels, reservoirs)

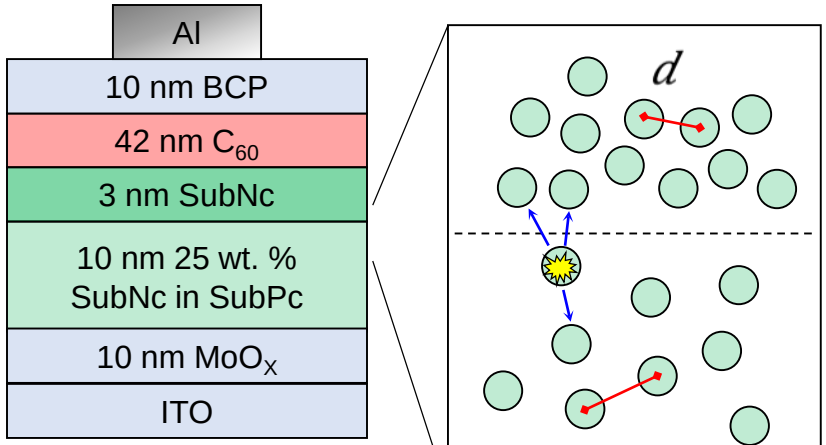
Transfer

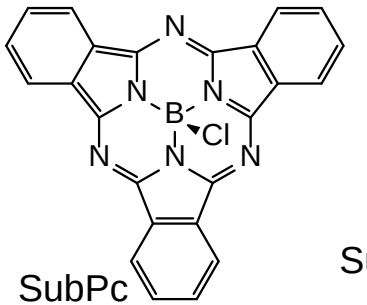


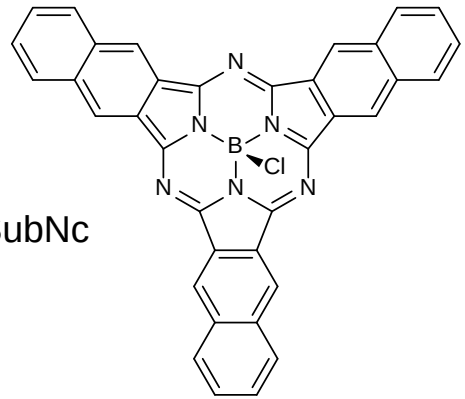
Devices

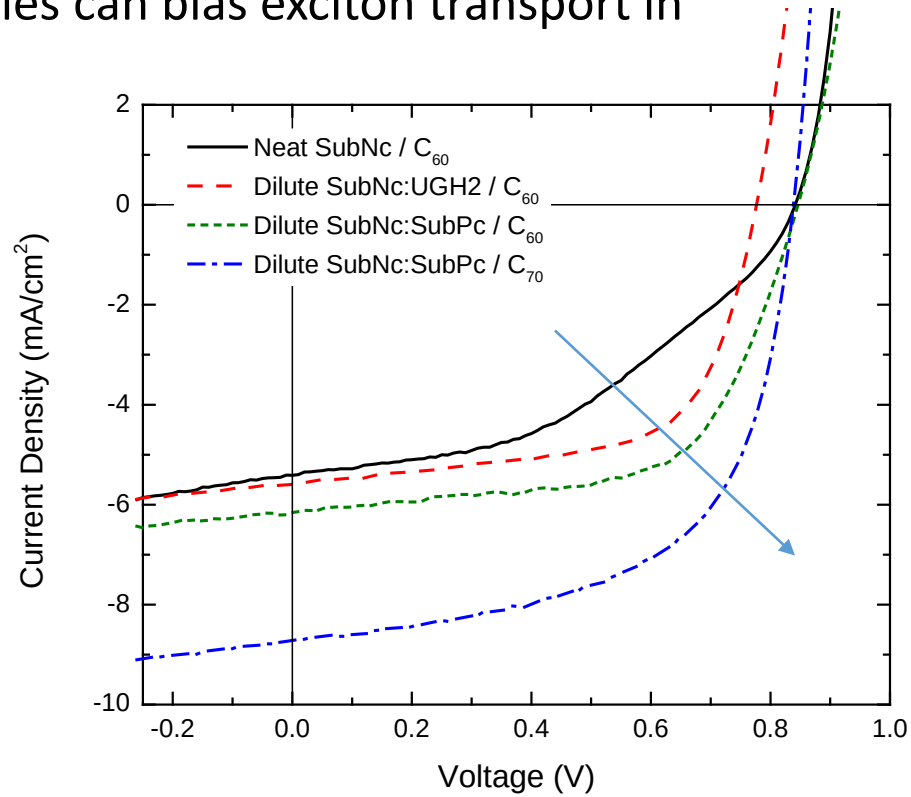
Increased Efficiency in Cascade Organic Solar Cells with Exciton Gates

- Organic solar cells are intrinsically limited by inefficient exciton diffusion – Interfaces with asymmetric site densities can bias exciton transport in preferred directions







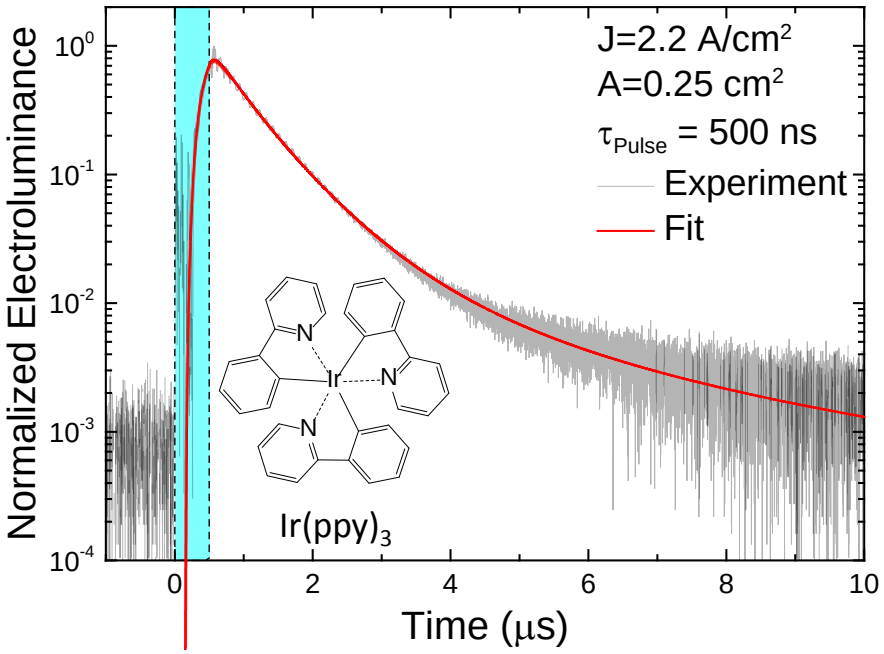


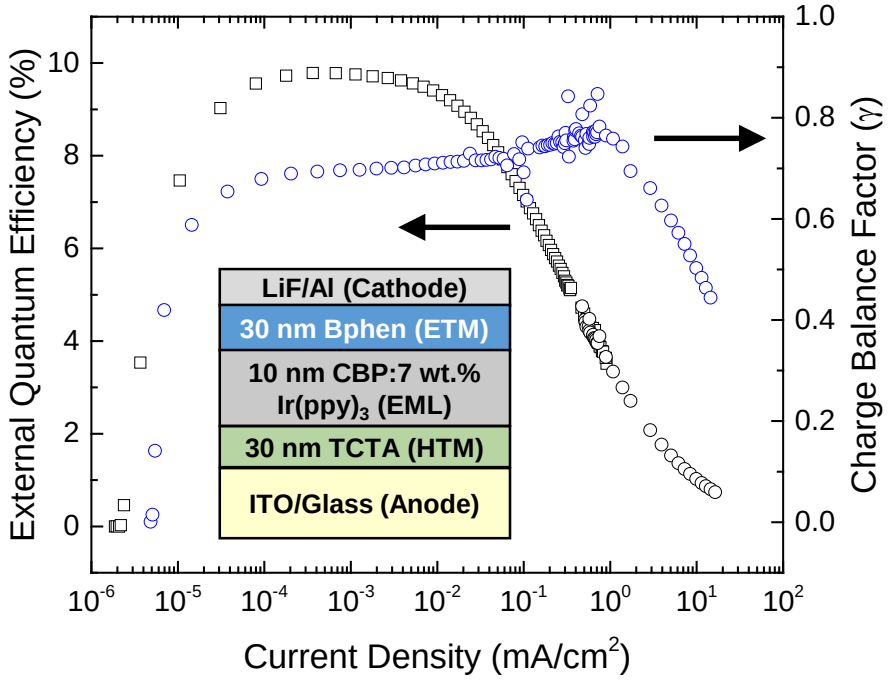
Performance increases with the use of multiple active materials (SubPc, SubNc) and the inclusion of a gating interface

Menke, Mullenbach, and Holmes ACS Nano 9, 4543 (2015), Menke and Holmes ACS AMI 7, 2912 (2015)

Exciton and Carrier Dynamics in Organic Light-Emitting Device (OLEDs)

- Further improvements in OLED performance require an understanding of the underlying exciton and charge carrier dynamics
- Time-evolution of the charge carrier population is explicitly considered, permitting the modeling of steady-state and transient electroluminescence
- Charge balance factor can be rigorously defined as the exciton formation efficiency in dynamic terms





Hershey and Holmes J. Appl. Phys. 120, 195501 (2016)