Georgia Tech Institute for Electronics and Nanotechnology

Stretchable Electronics: Processing and Analyzing Blended P3HT-PDMS Devices

BY NICHOLAS THEUT

MENTOR: DR. GUOYAN ZHANG

PI: DR. ELSA REICHMANIS

National Nanotechnology Coordinated Infrastructure

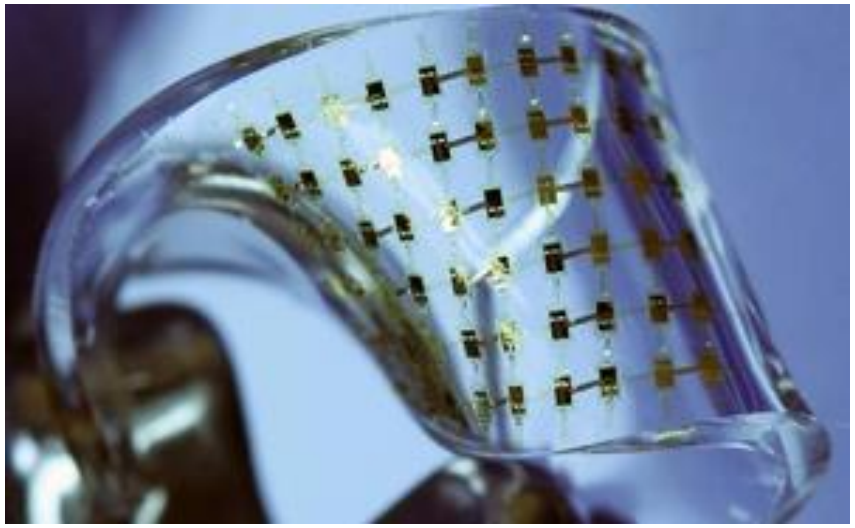
SENIC Southeastern Nanotechnology Infrastructure Corridor

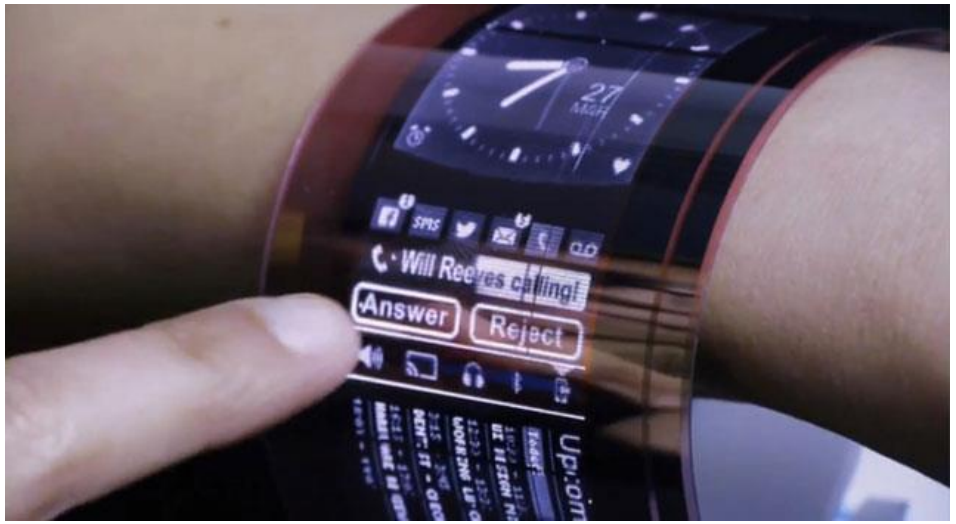
NSF

Applications of Stretchable Electronics

Biomedical applications
Wearable Electronics
Soft Robotics

Use of polymers:
Biodegradable
Low cost
Easy Processing

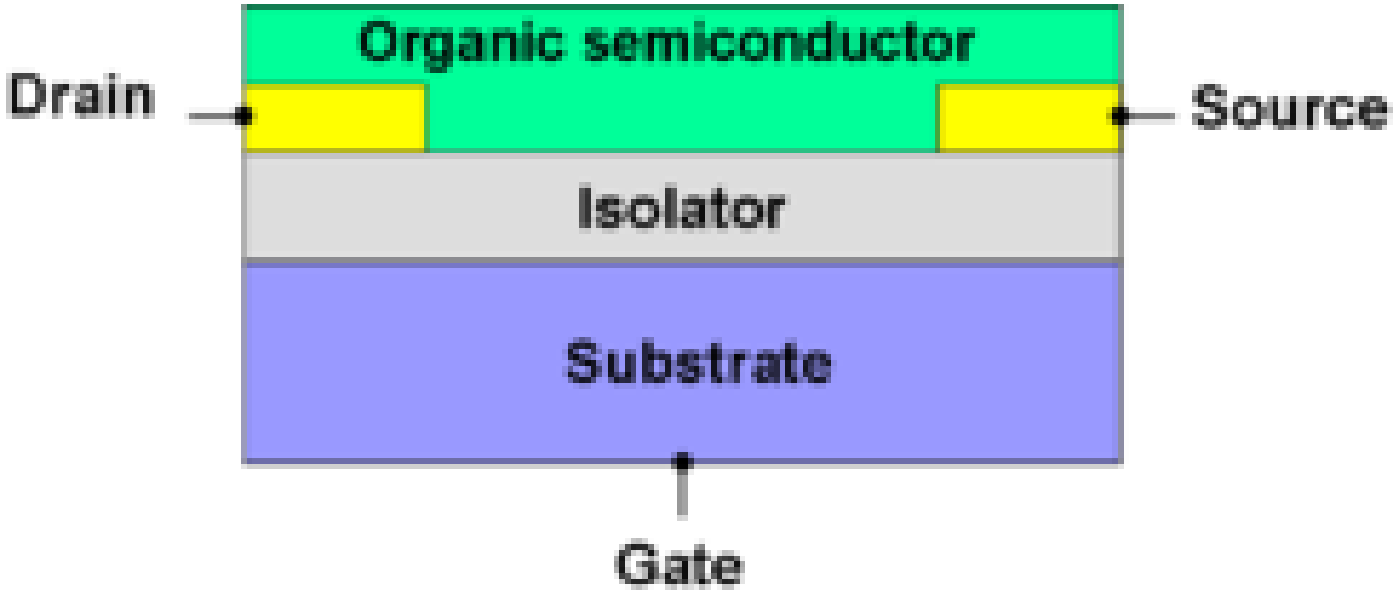




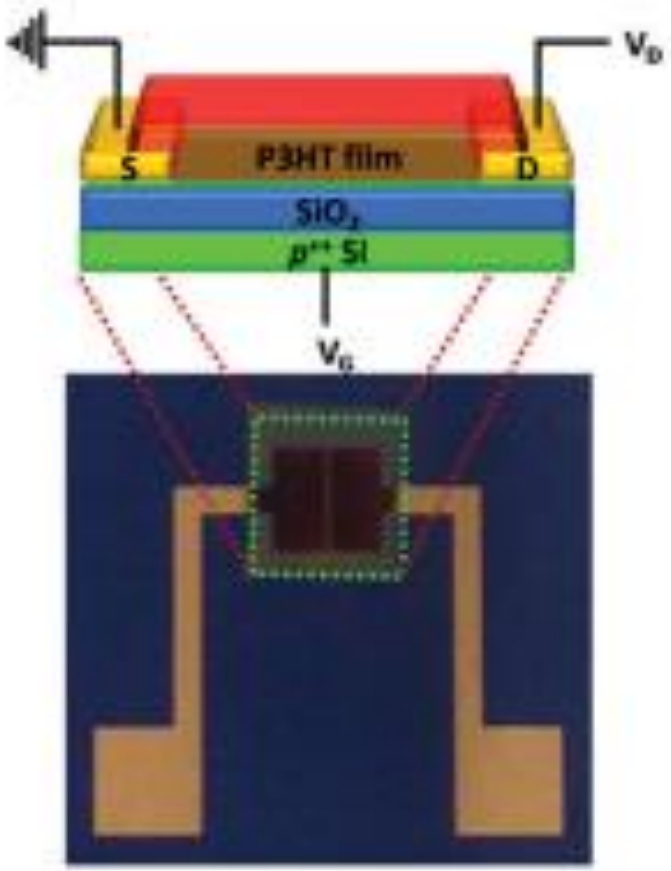
Stretchable Electronics

Goal: Create High Mobility Stretchable Polymer System

First test on Silicon Substrate then create Flexible Device



Organic Field Effect Transistor (OFET)



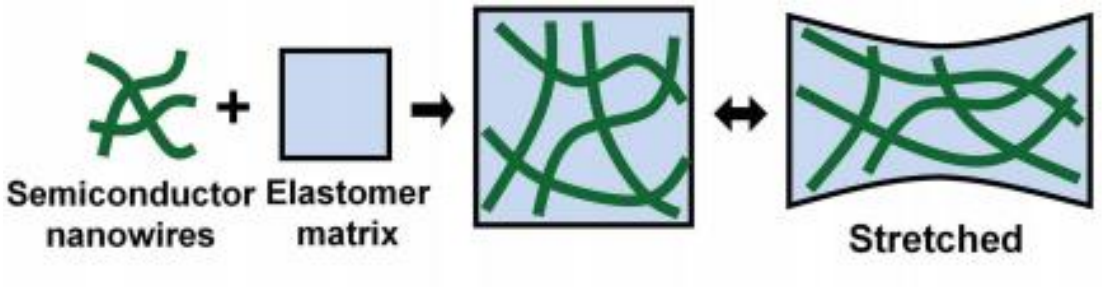
Blended Polymer Systems

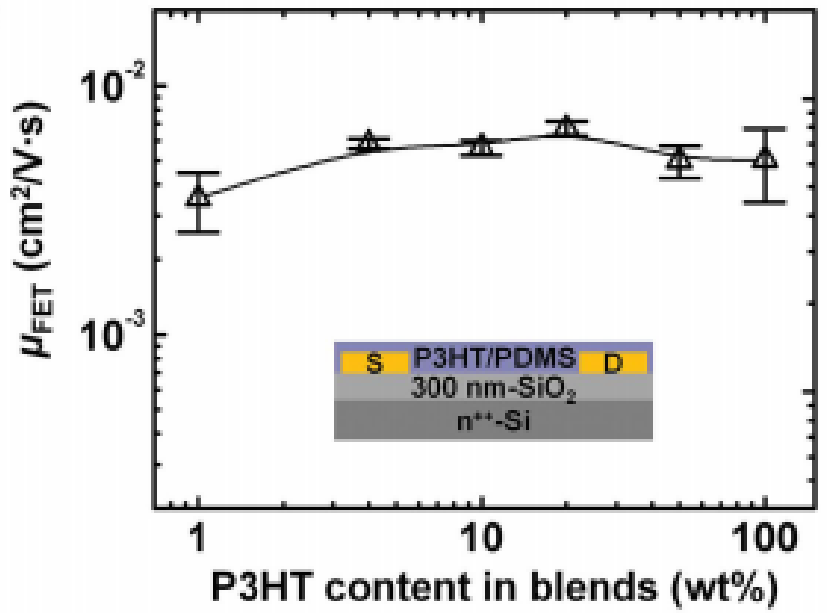
Showed similar electronic properties to pristine semiconducting polymer

Cheaper than patterning and large structure polymer creation

Faster and easier processing

Better property retention with stretching



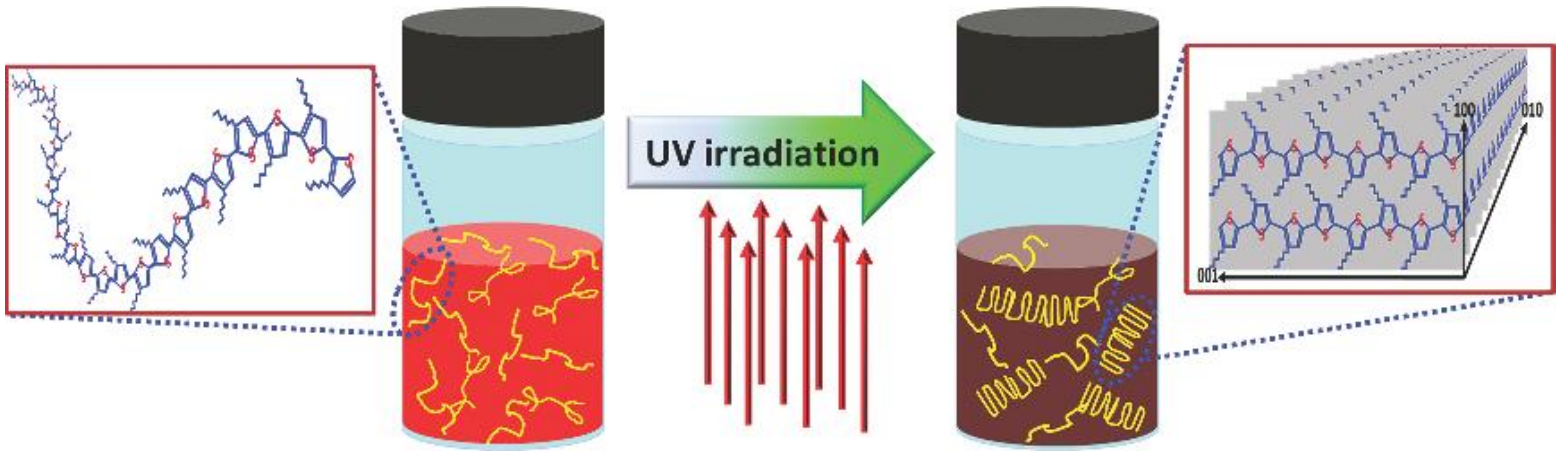


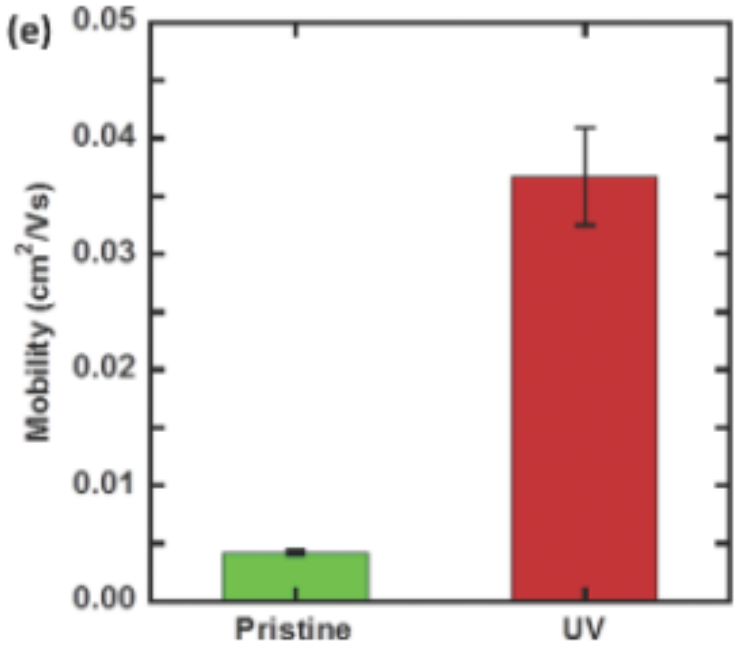
Song E., Kang B., Choi H. H., Sin D. H., Lee H., Lee W. H., Cho K. (2016). Stretchable and Transparent Organic Semiconducting Thin Film with Conjugated Polymer Nanowires Embedded in an Elastomeric Matrix. Adv. Electron. Mater., 2: 1500250. doi: 10.1002/aelm.201500250

UV light exposure

8 minutes – maximum aggregation of P3HT achieved and highest mobility

UV Light exposure facilitates aggregation within pristine P3HT





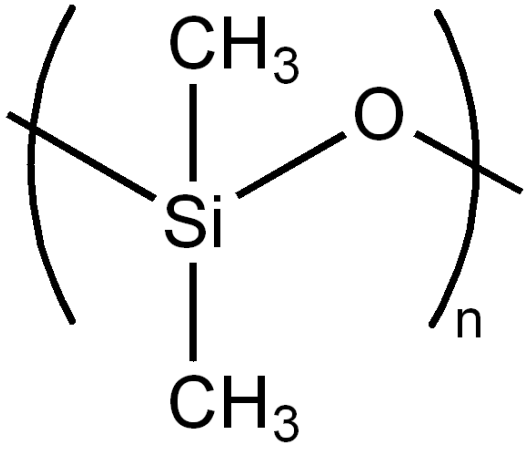
Chang, M., Lee, J., Kleinhenz, N., Fu, B. and Reichmanis, E. (2014), Photoinduced Anisotropic Supramolecular Assembly and Enhanced Charge Transport of Poly(3-hexylthiophene) Thin Films. Adv. Funct. Mater., 24: 4457–4465. doi:10.1002/adfm.201400523

My Research: Process blended P3HT-PDMS with varying times of UV exposure and analyze the results

My Blended Polymer System

PDMS (Polydimethylsiloxane)

- Elastomer and Insulator
- Low-cost and Transparent

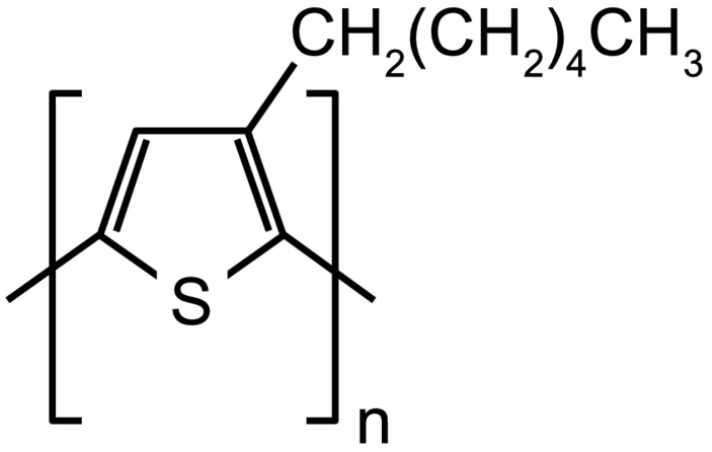


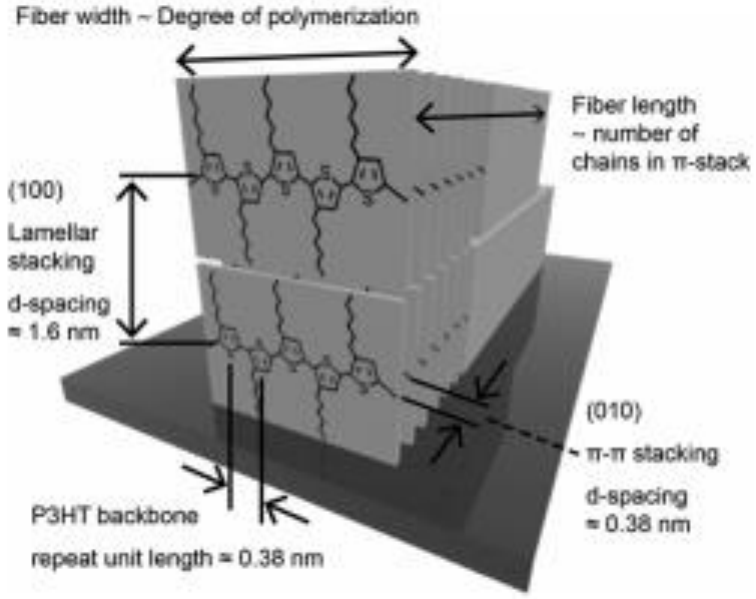
P3HT (Poly(3-hexylthiophene-2,5-diyl))

Semiconducting polymer

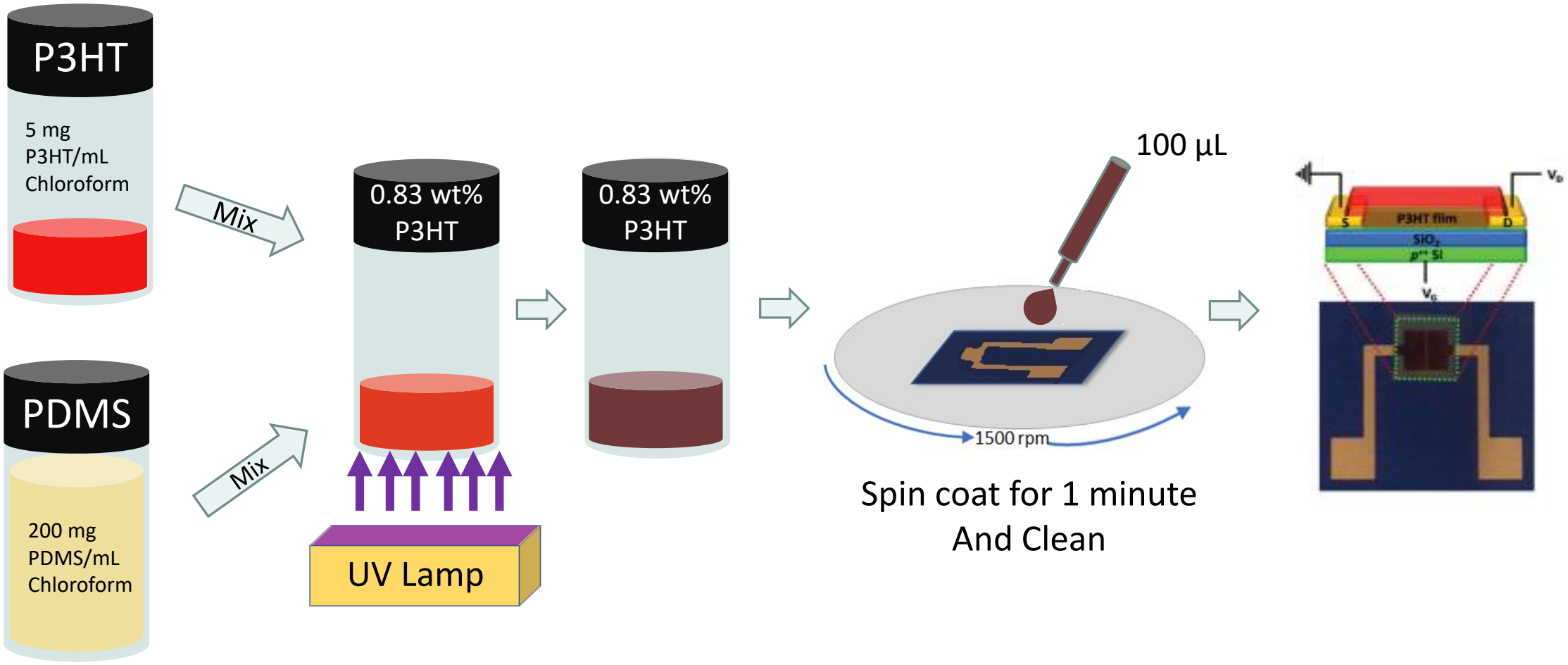
Used a good model for aggregation

Cheaper than higher mobility polymers



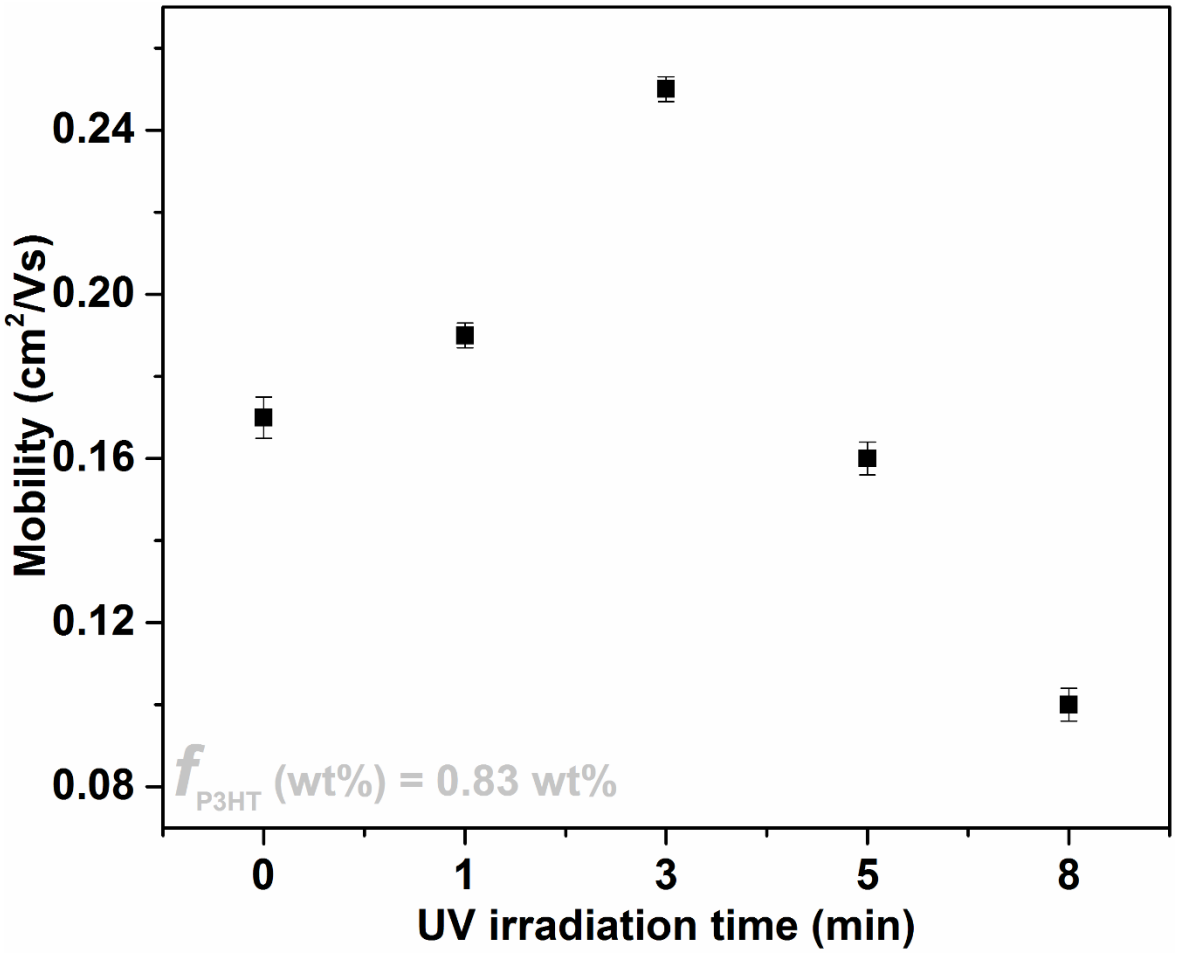


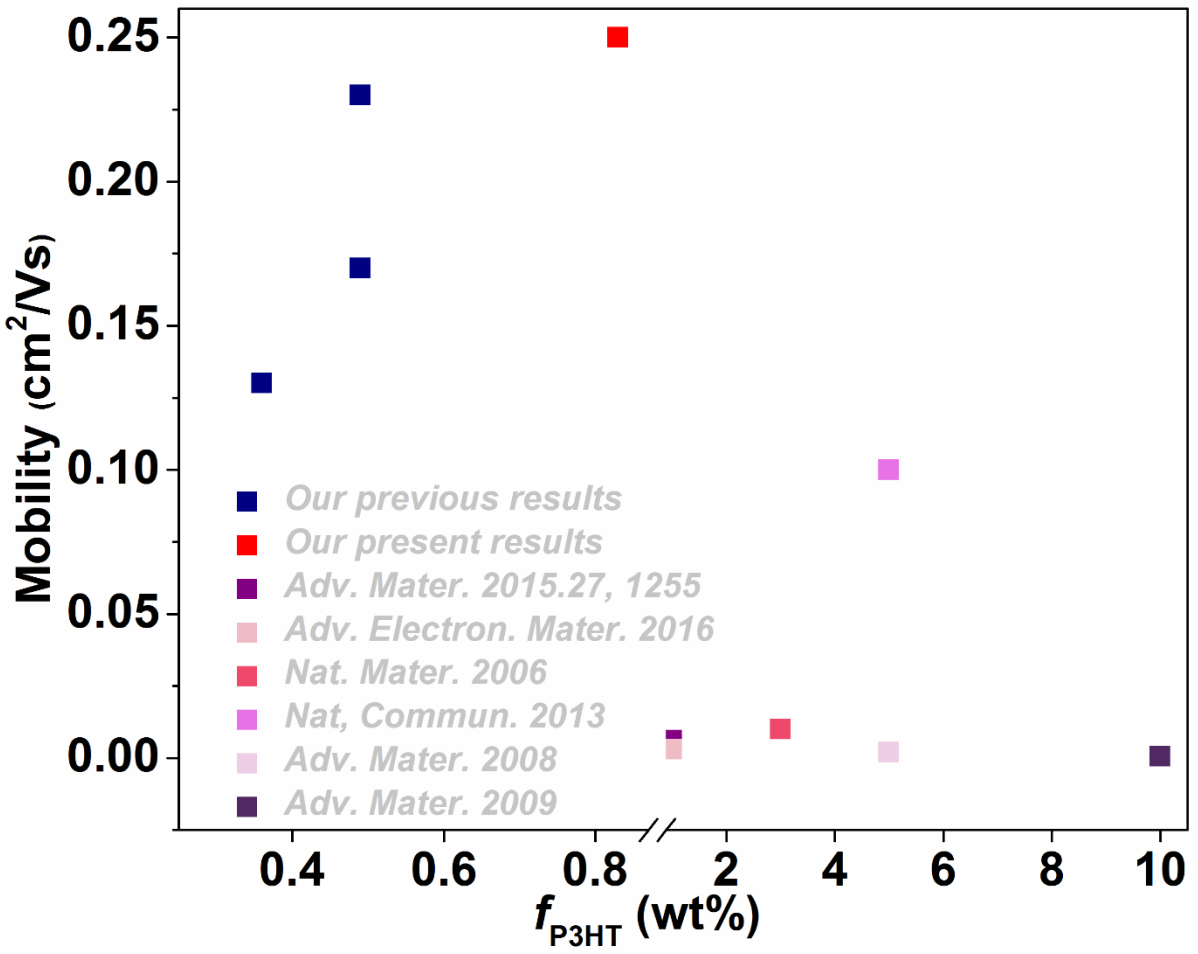
Device Synthesis



Spin coat for 1 minute
And Clean

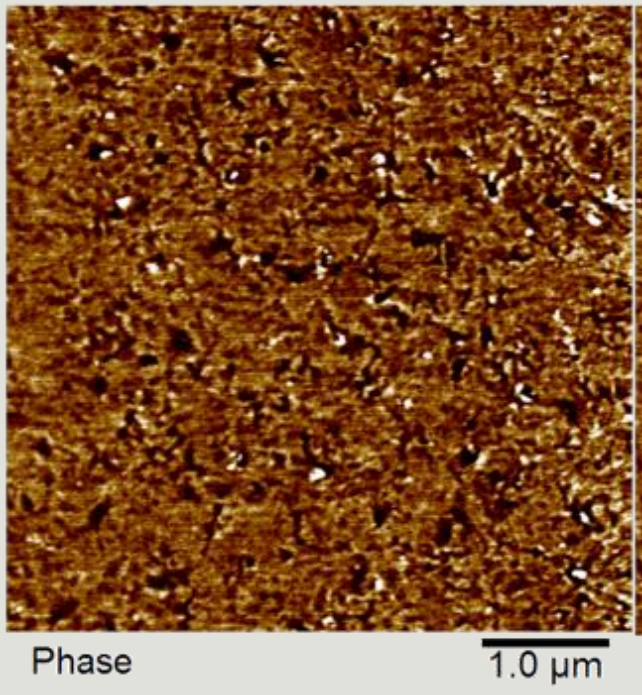
Electronic Properties



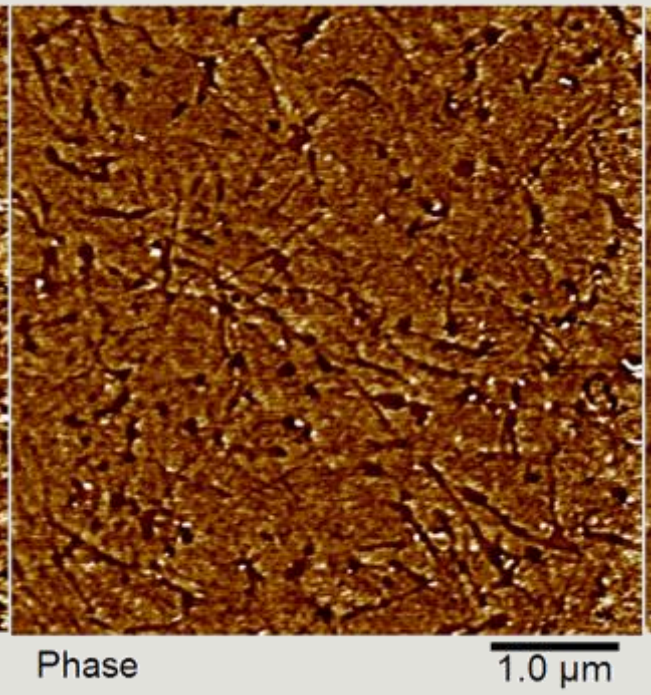


Atomic Force Microscopy (AFM) Images – Bottom Layer Morphology

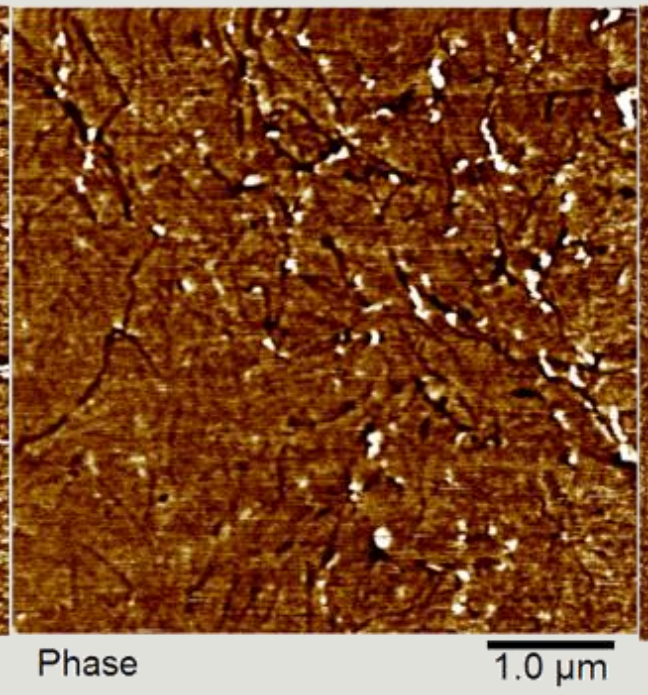
1 min UV



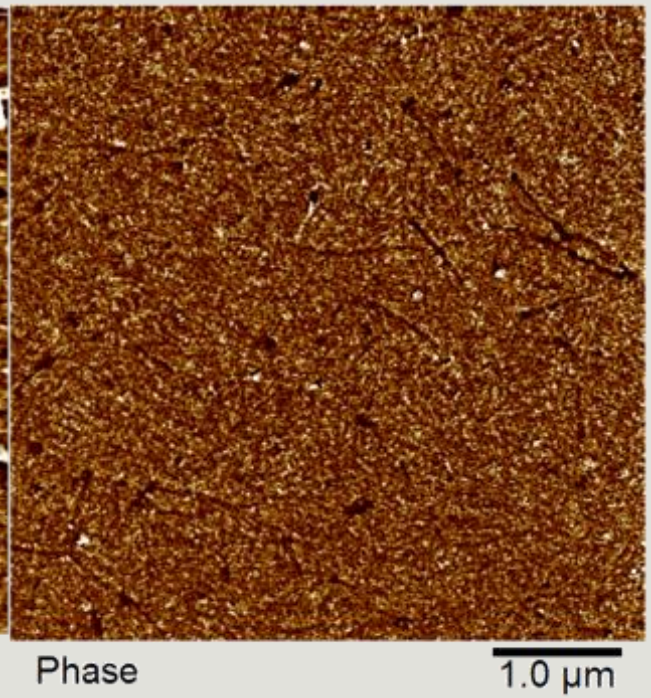
3 min UV



5 min UV

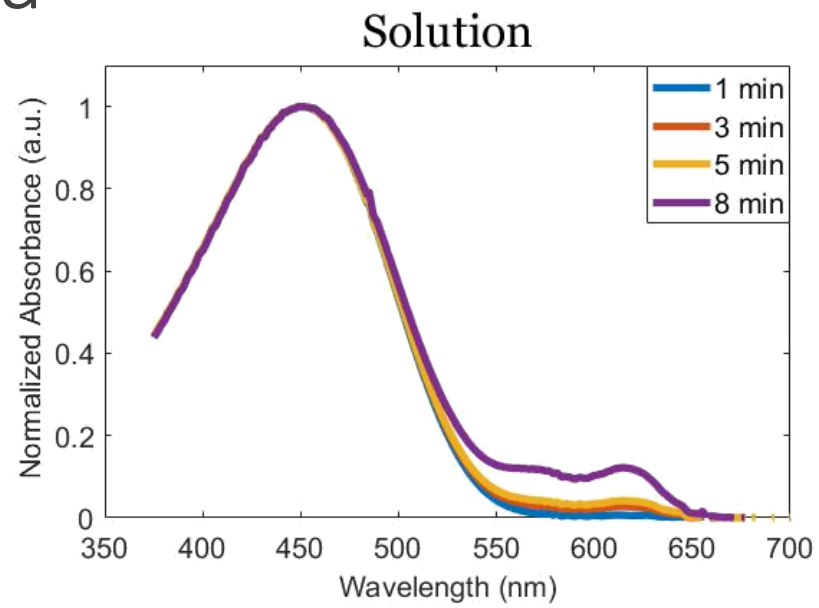


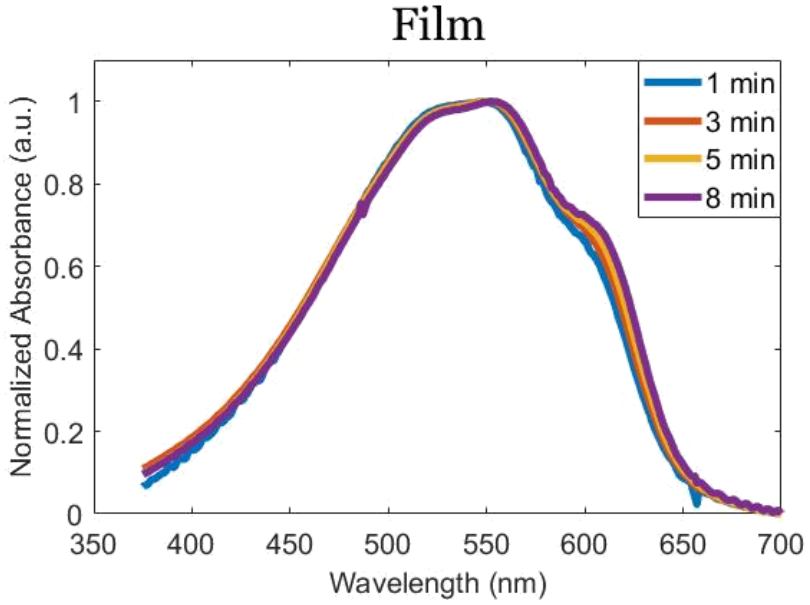
8 min UV



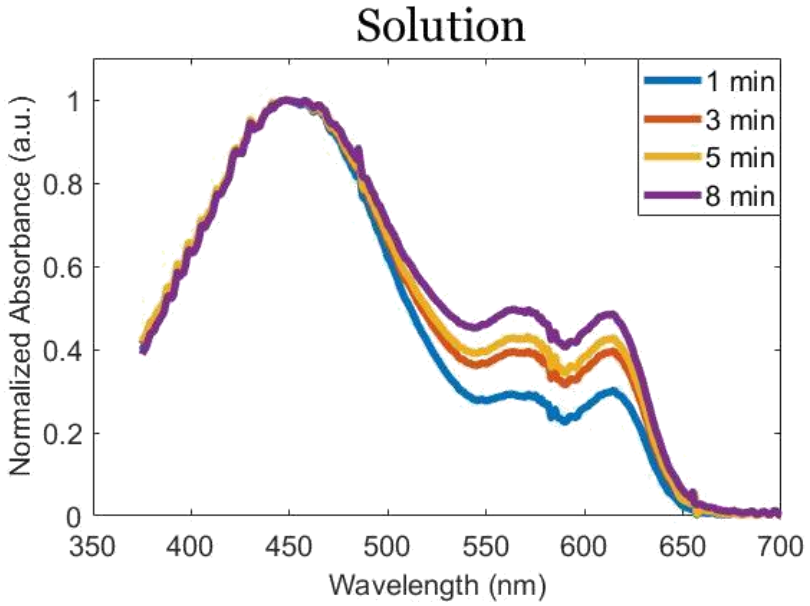
UV-vis spectra

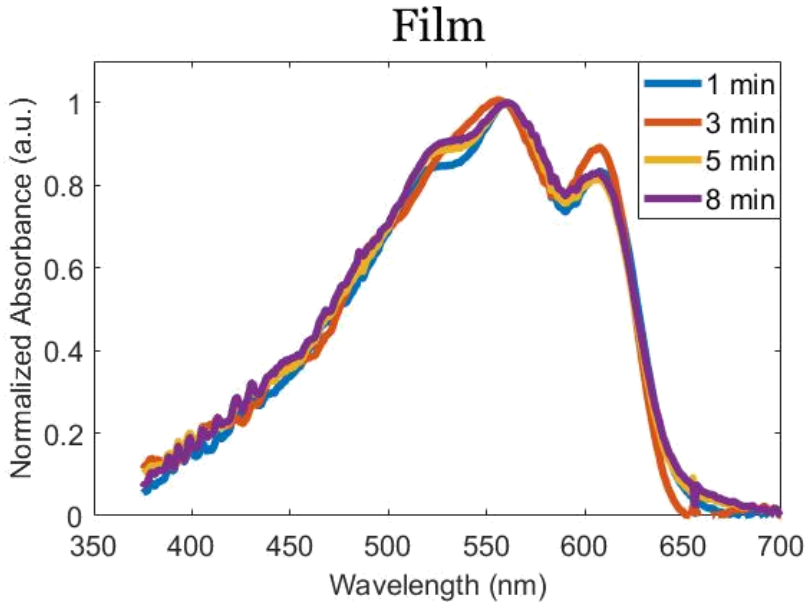
P3HT Only





P3HT-PDMS
(0.83 wt% P3HT)





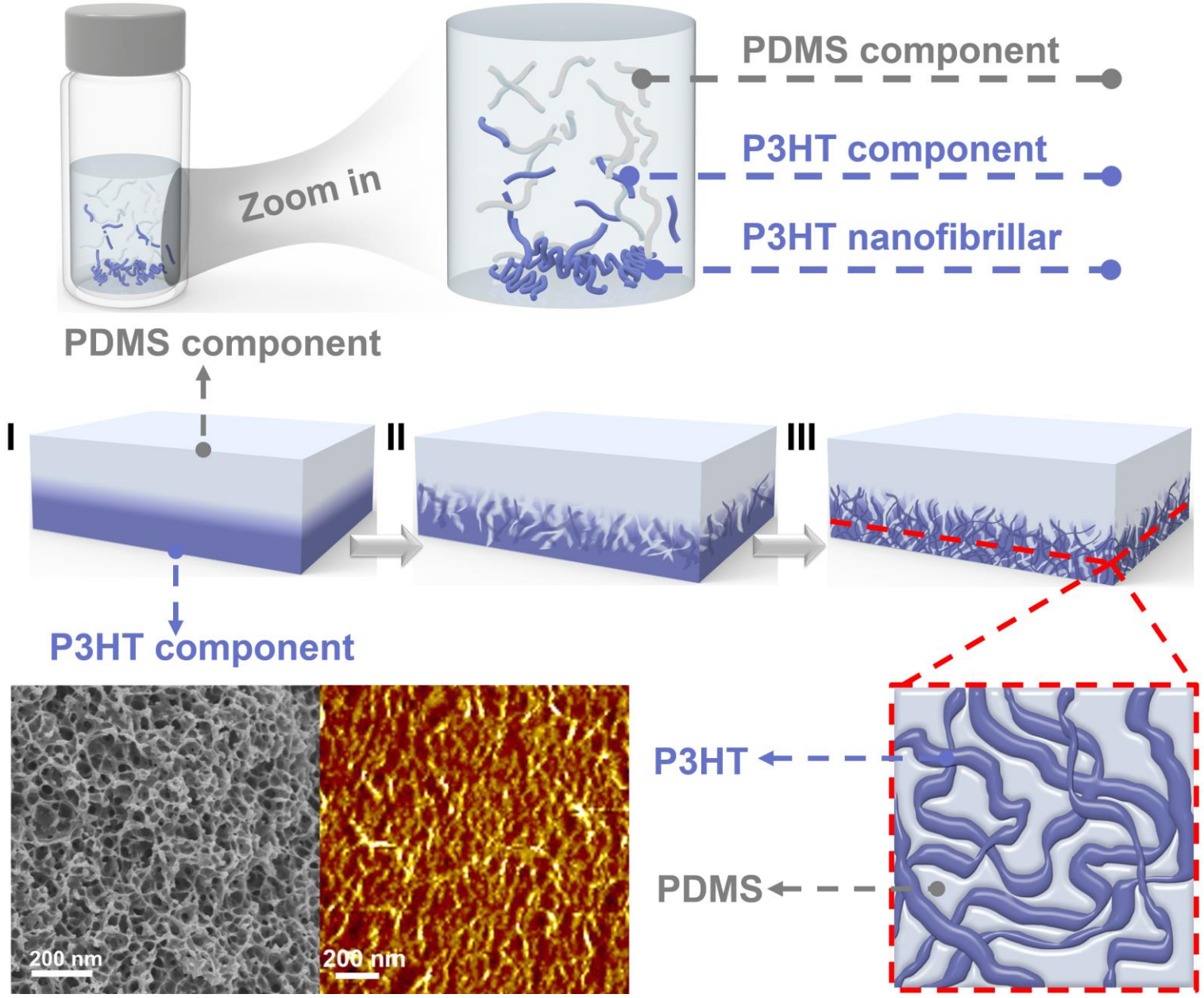
Mechanism

Originally produced by mentor: Dr. Guoyan Zhang

Unfavorable interactions between PDMS and P3HT

P3HT migrates toward the Silicon interface and forms nano-crystallite network

Electronic Mobility optimized for 3 minutes of UV exposure whereas pure P3HT showed optimization at 8 minutes



Conclusion

1. Optimized Ultraviolet light exposure for P3HT-PDMS Blend (0.83 wt% P3HT)

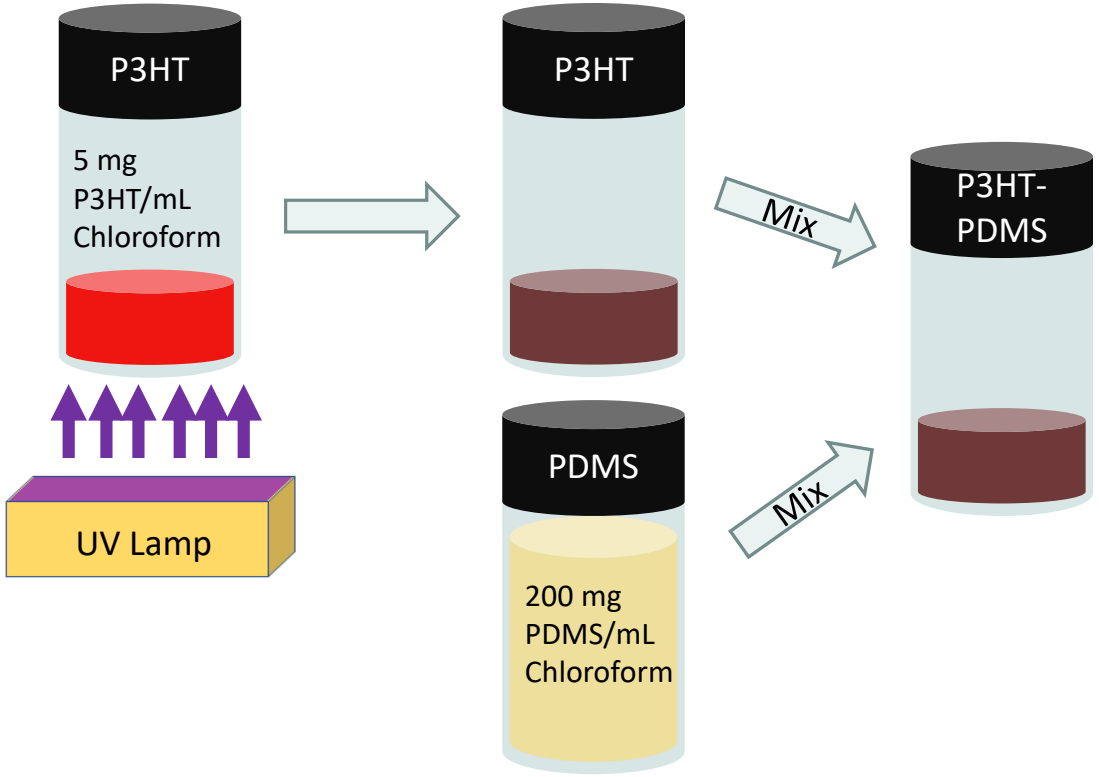
   Three minutes was the optimum exposure time
2. A very low fraction of P3HT (0.83 wt%) can reach very high mobilities

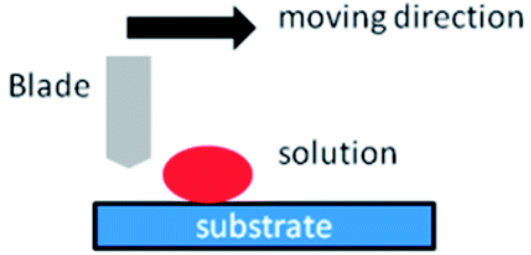
3. AFM images and UV-vis spectra show phase separation and the formation of a network structure

Future Work

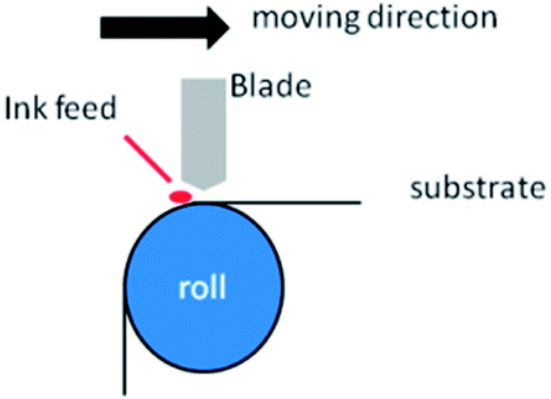
UV Exposure to P3HT prior to Mixing

Blade Coating and Cleanroom Conditions for further improvement





Doctor blade

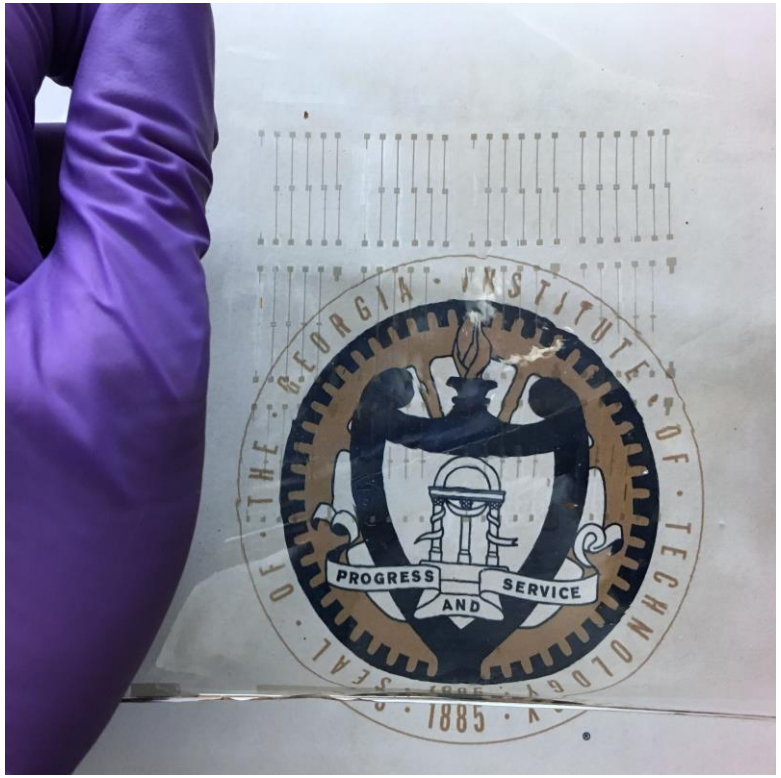


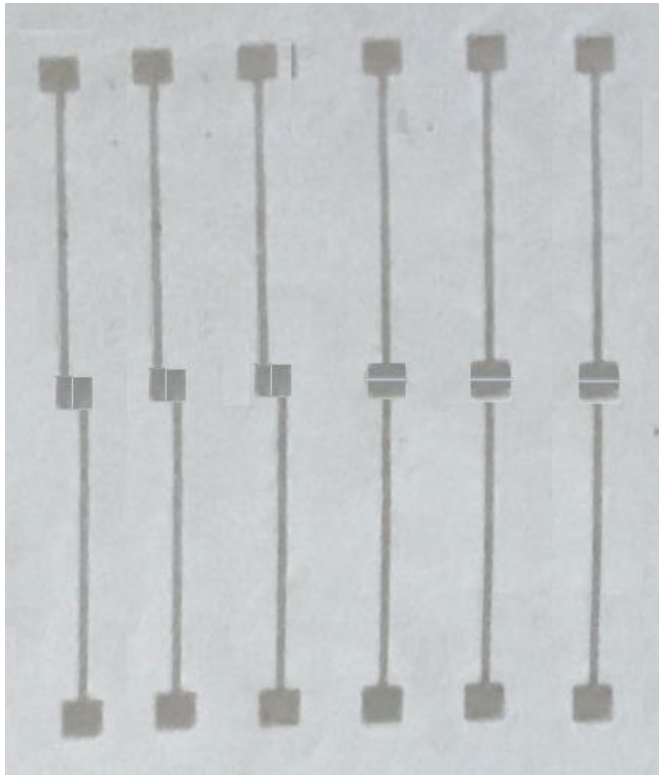
Knife-over-edge

Future Work

Create Fully Stretchable Devices using this Blended Polymer System

Test the Electronic and Mechanical Properties of the Device





Thank You, Are There Any Questions?

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SUIN program