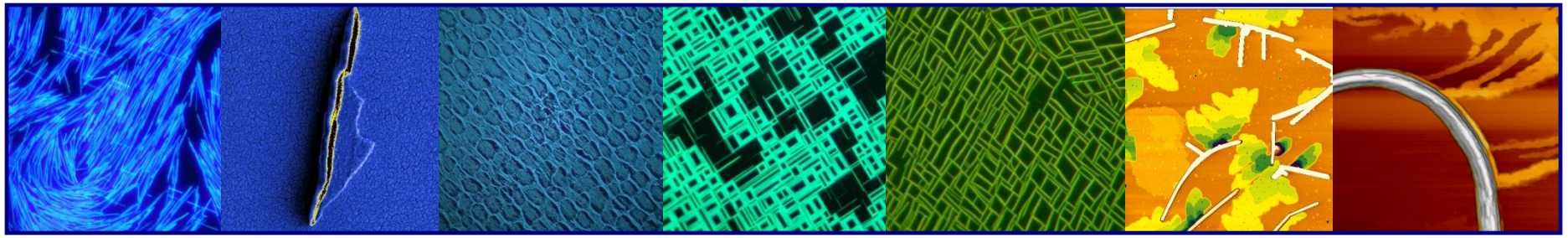


Nanostructures for Organic Solar Cells

Morten Madsen

NanoSYD, The Mads Clausen Institute

University of Southern Denmark

Nanotechnology at NanoSYD

Top down microtechnology allows microscale structure formation on device platforms

Bottom up nanotechnology allows self organized formation of crystalline nanoaggregates

Combination of top down and bottom up technology results in **'self growing photonics and electronics for advanced lighting and energy production'**
The growth of optimum nano-scaled aggregates is triggered by the micro-nanostructures

Alsion with nanotechnology center NanoSYD

Organic Solar Cells at NanoSYD

Assistant Professor: Morten Madsen
Postdoc: Roana Melina de Oliveira Hansen
PhD: Michal Radziwon
PhD: Arkadiusz Goszczak (new)
PhD: André Cauduro (new)
Master and Bachelor students

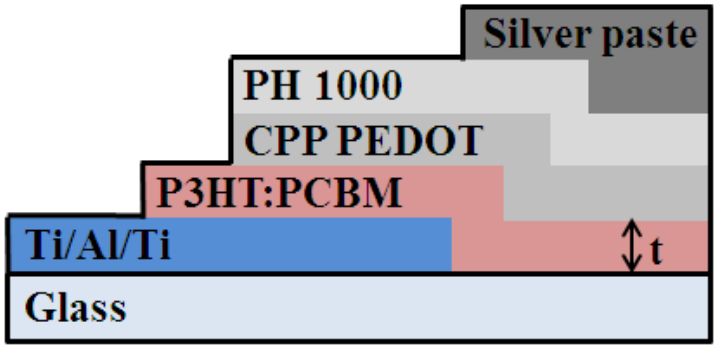
Polymer Bulk-heterojunction solar cells

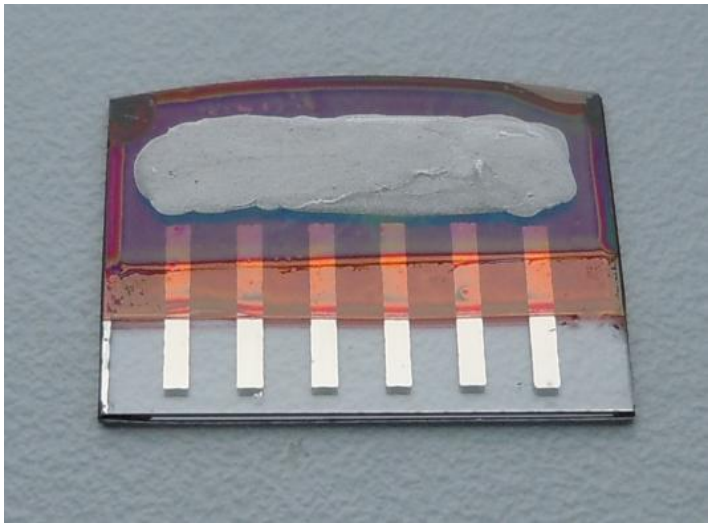
- Flexible polymer solar cells with structured back-electrodes for increased light-trapping
- Stability of polymer solar cells
- Nanostructured polymer solar cells

Small molecule solar cells from nanocrystals

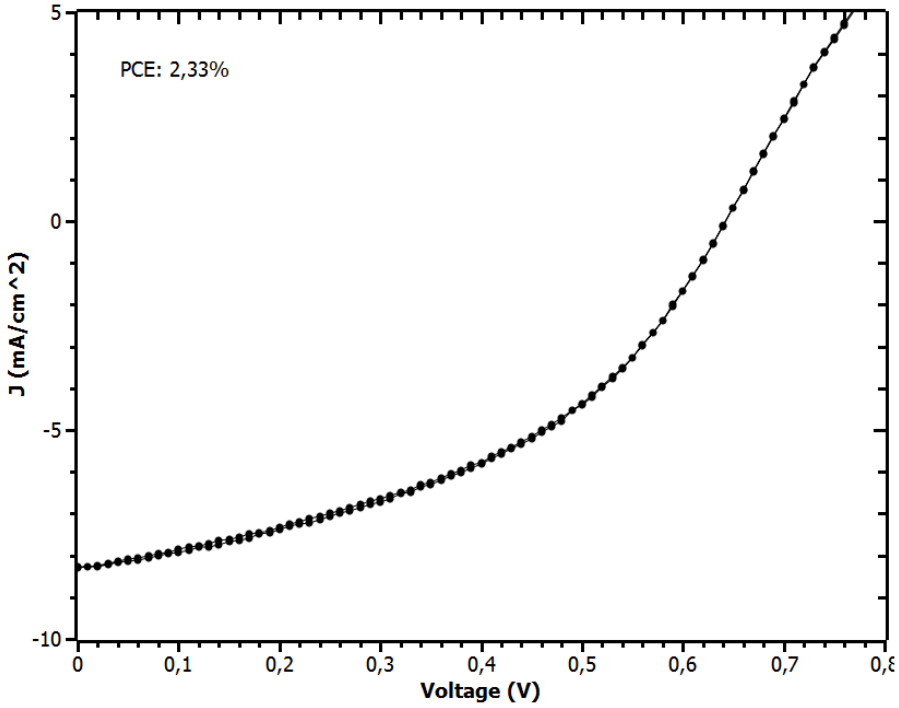
- Small molecule nanostructures for solar cell devices

Inverted bulk-heterojunction solar cells



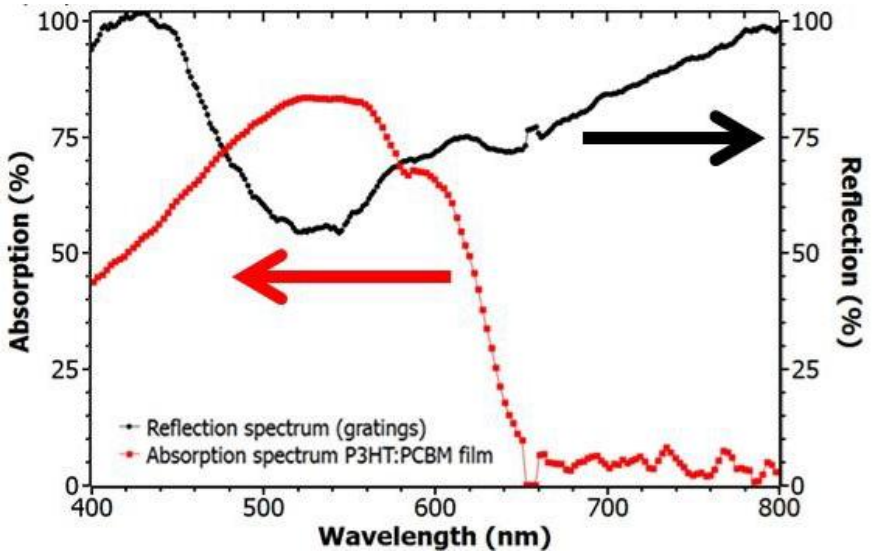


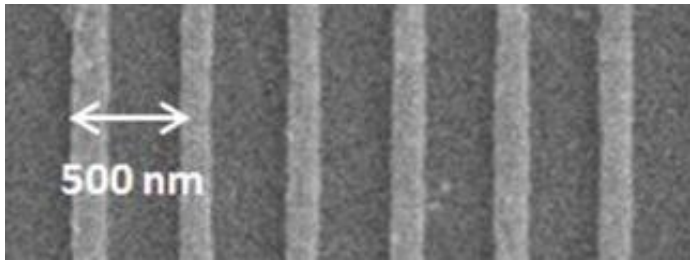
Fabrication (left) and I-V characterization (bottom) of ITO-free inverted solar cells



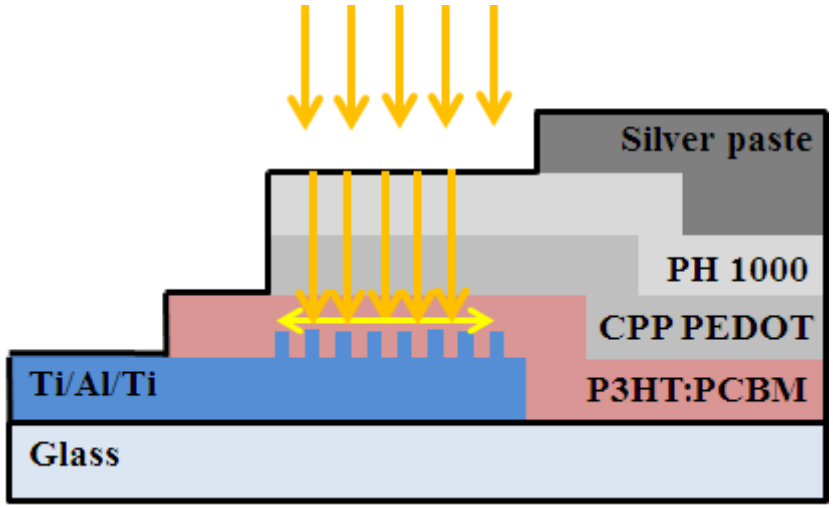
Structured back electrodes

- Increasing light trapping and efficiency





Integration of metal gratings at the back electrode increases absorption and efficiency of the cells



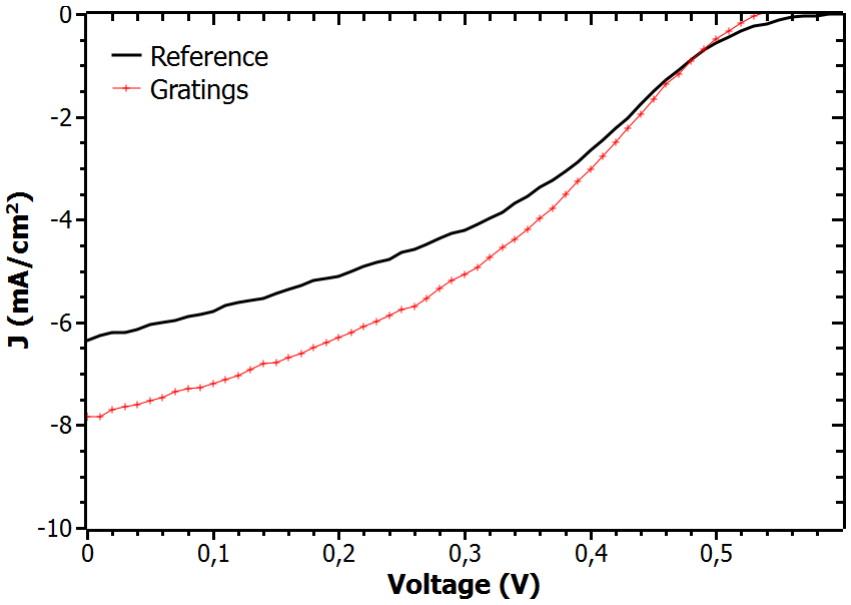
Proceedings of SPIE 8438-38 (2012)

Structured back electrodes

- Increasing light trapping and efficiency

Integration of metal nanostructures at the back electrode increases absorption and efficiency of the cells

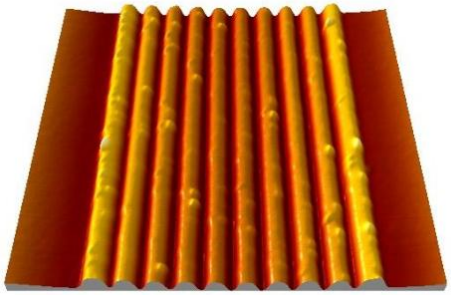
Parameter	Reference	Gratings
Jsc(mA/cm^2)	6.36	7.83
Voc (V)	0.58	0.53
FF (%)	34.4	36.8
PCE (%)	1.27	1.53
PCE Enhancement (%)		20

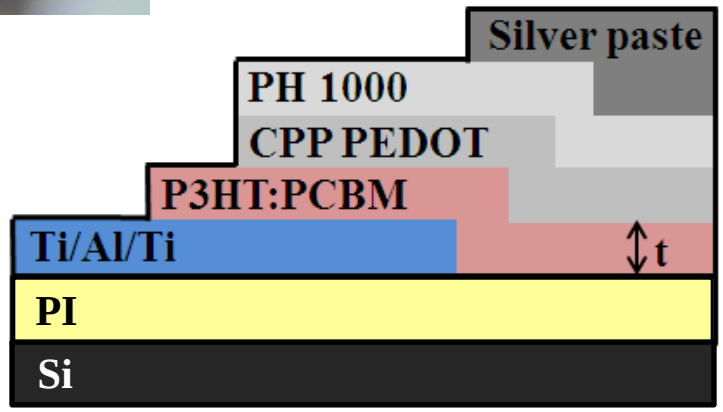


Proceedings of SPIE 8438-38 (2012)

Flexible nanostructured solar cells

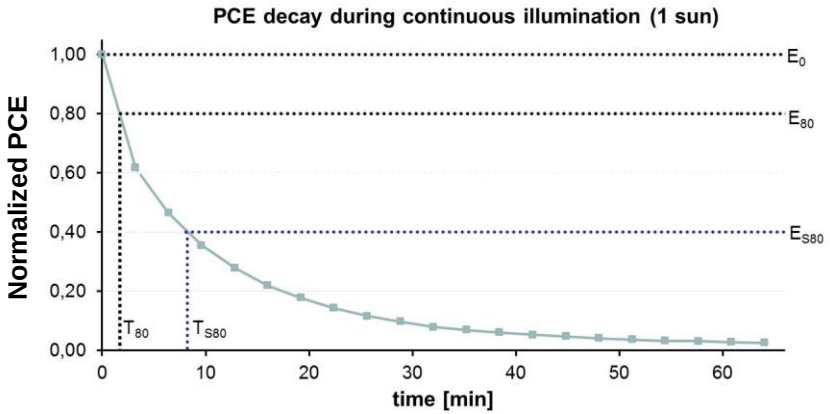
Polyimide is thin, flexible and compatible with standard lithography processes.



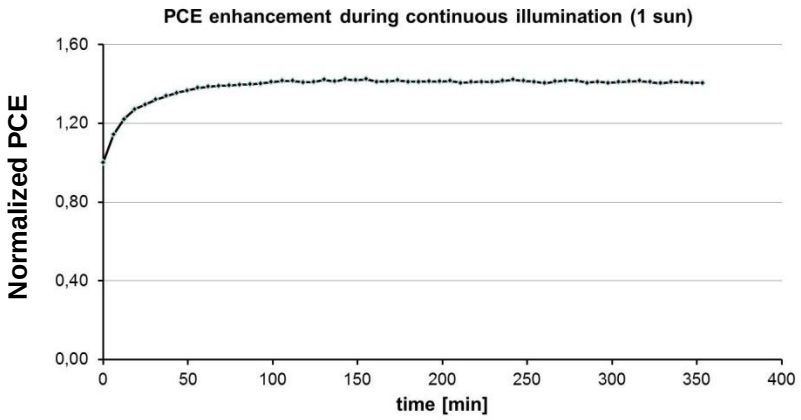


Stability of polymer solar cells

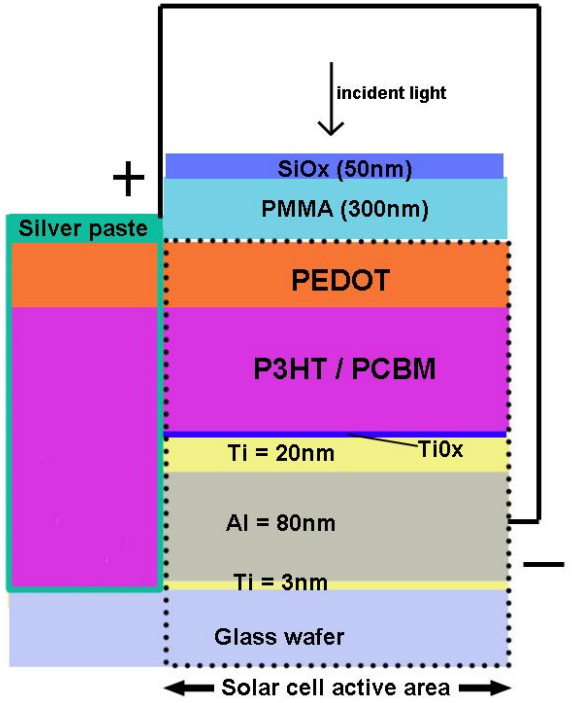
Non-encapsulated cell



Encapsulated cell

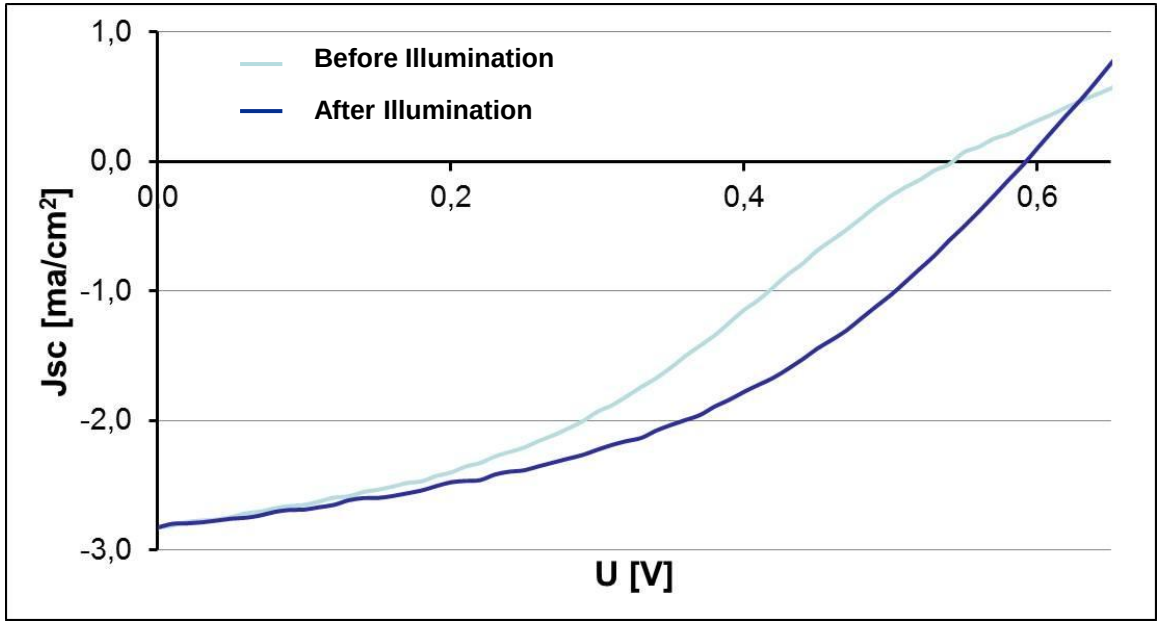


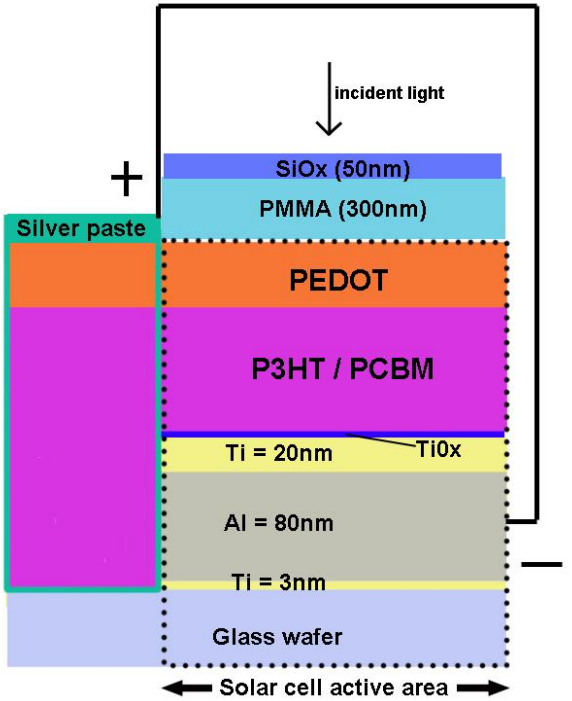
Encapsulation improves both the solar cell lifetime and efficiency



Stability of polymer solar cells

Encapsulated solar cell

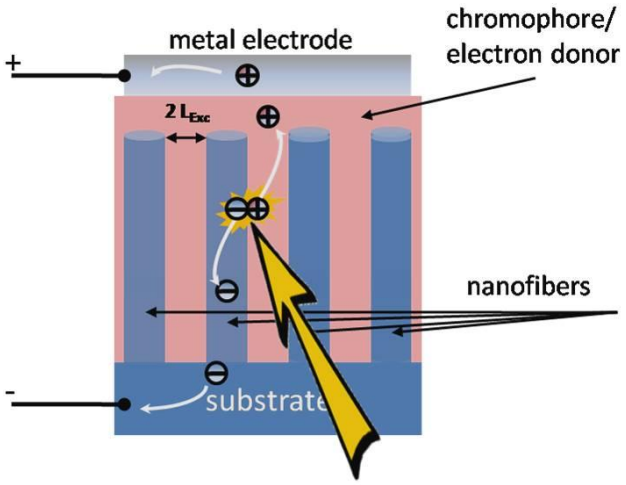


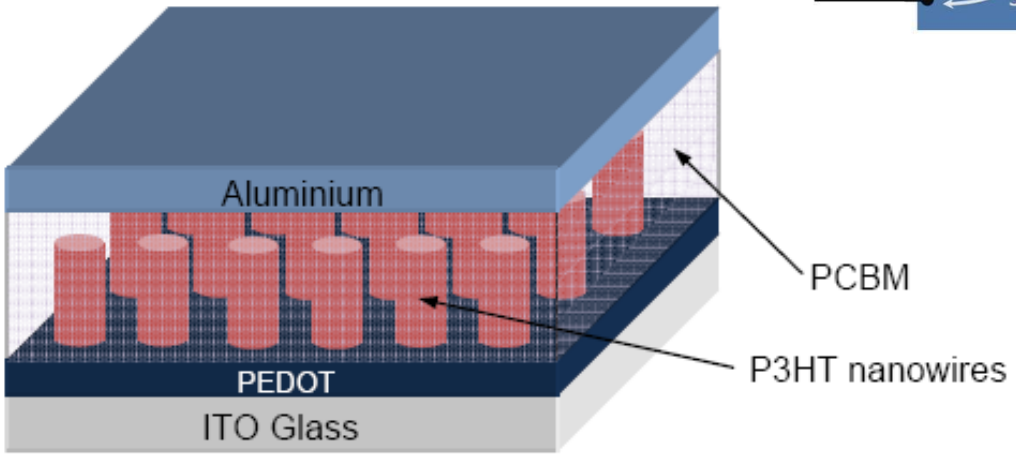


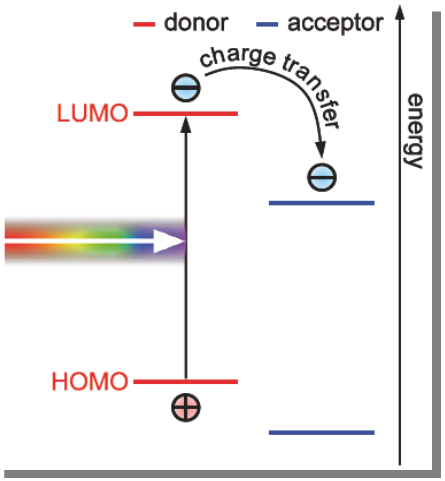
Nanostructured Organic Solar Cells

Increase efficiency of polymer solar cells

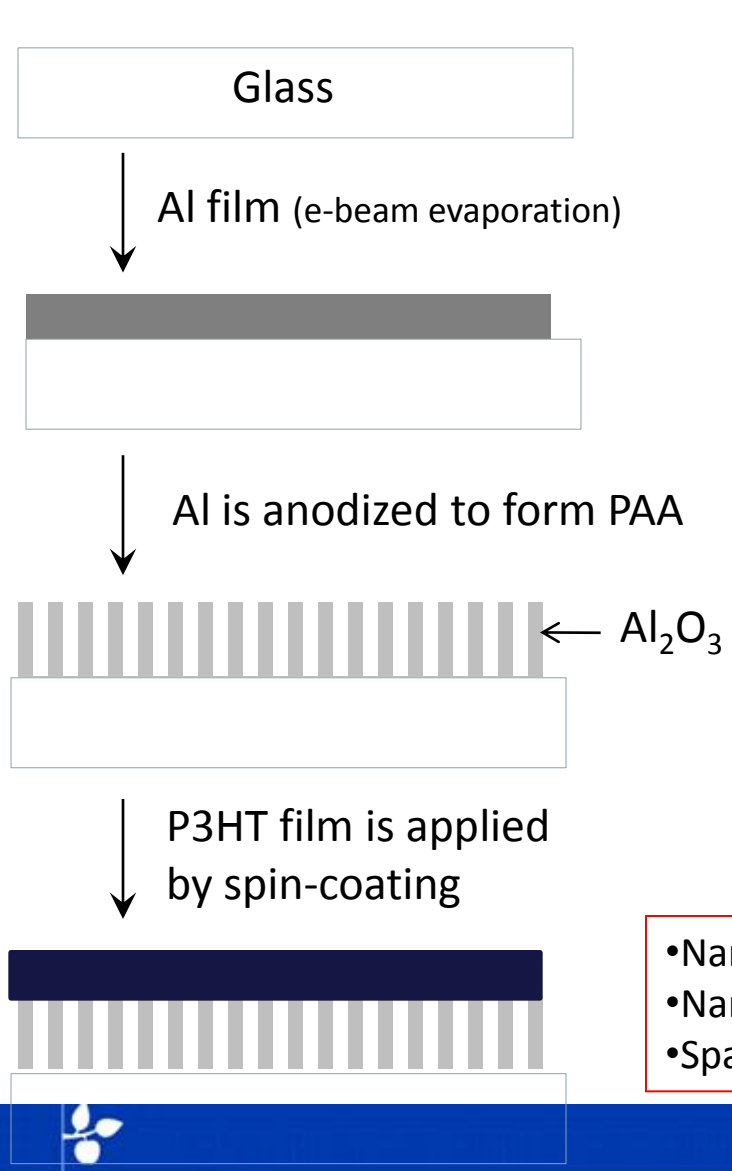
via nano structure formation

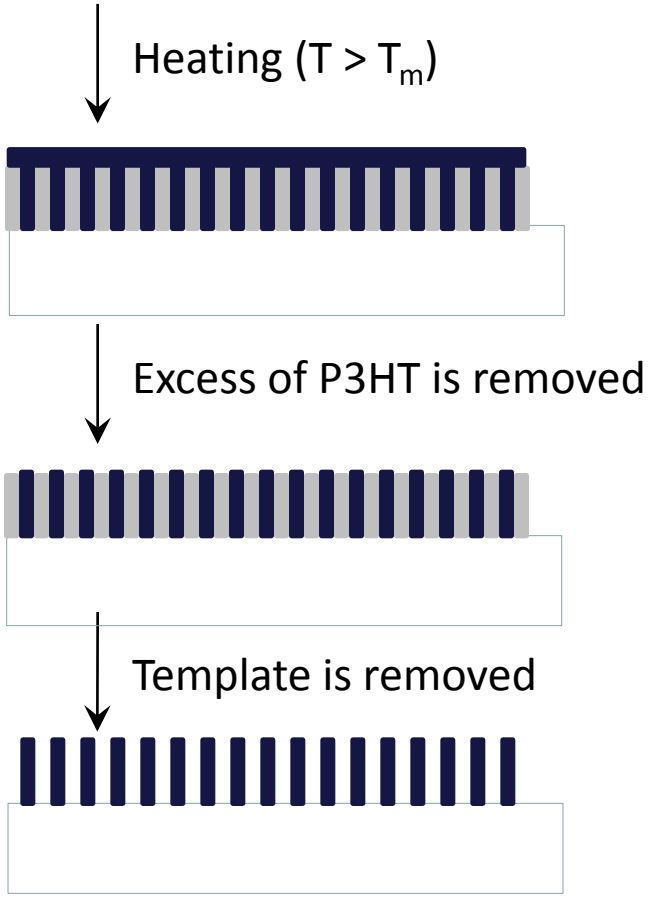






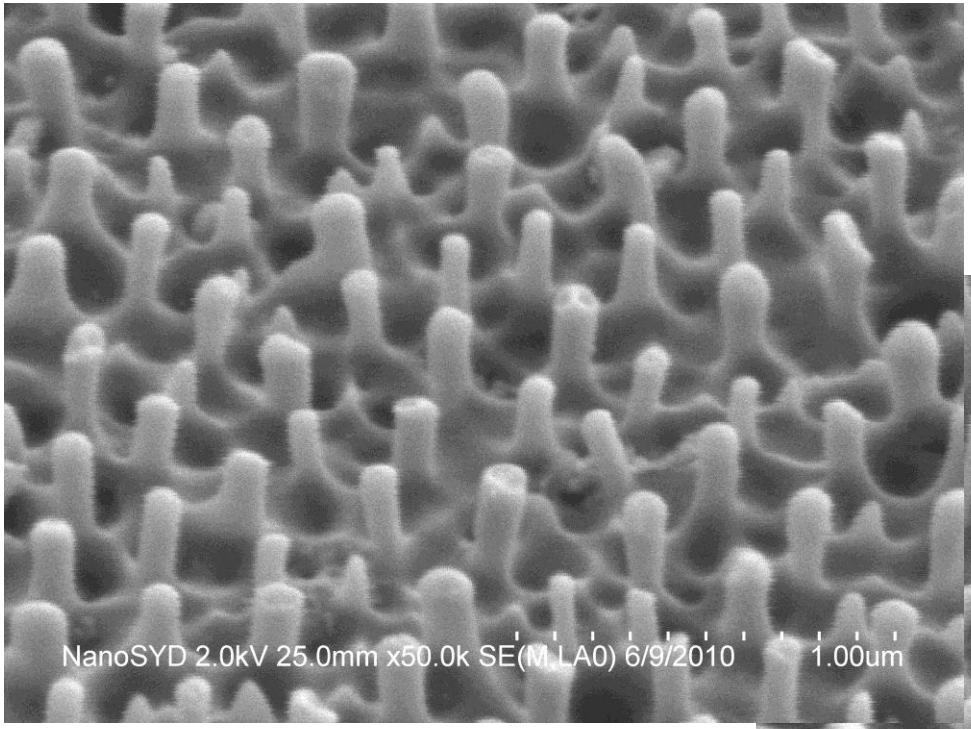
P3HT nanopillars from nano-imprint

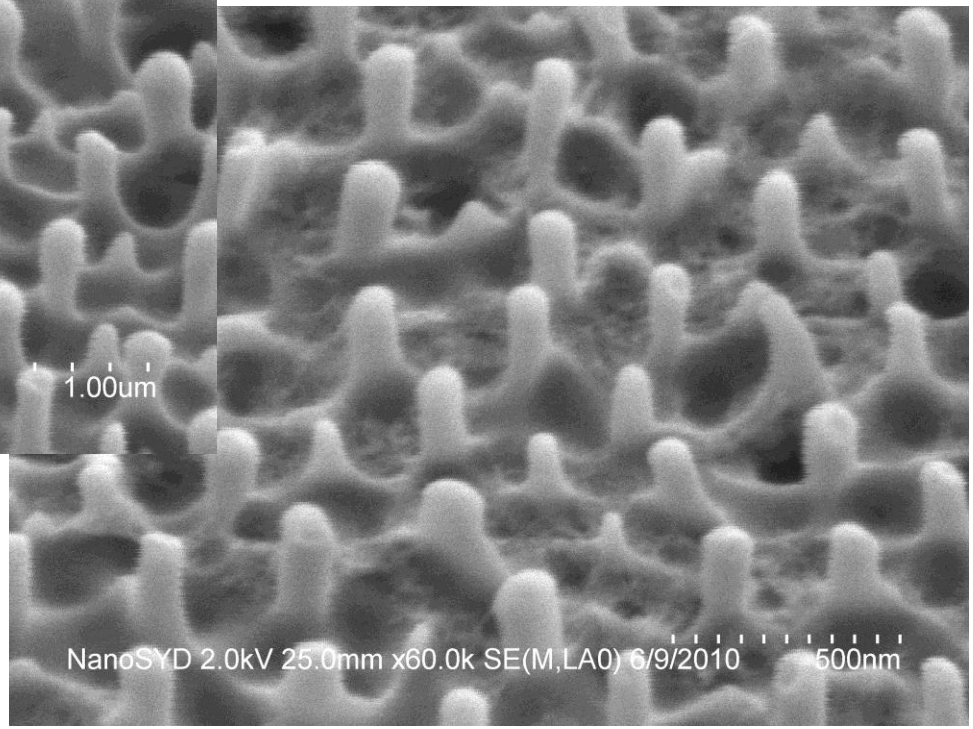




- Nanowire diameter: 30-40 nm
- Nanowire height: 100-150 nm
- Spacings between nanowires: 50-100 nm

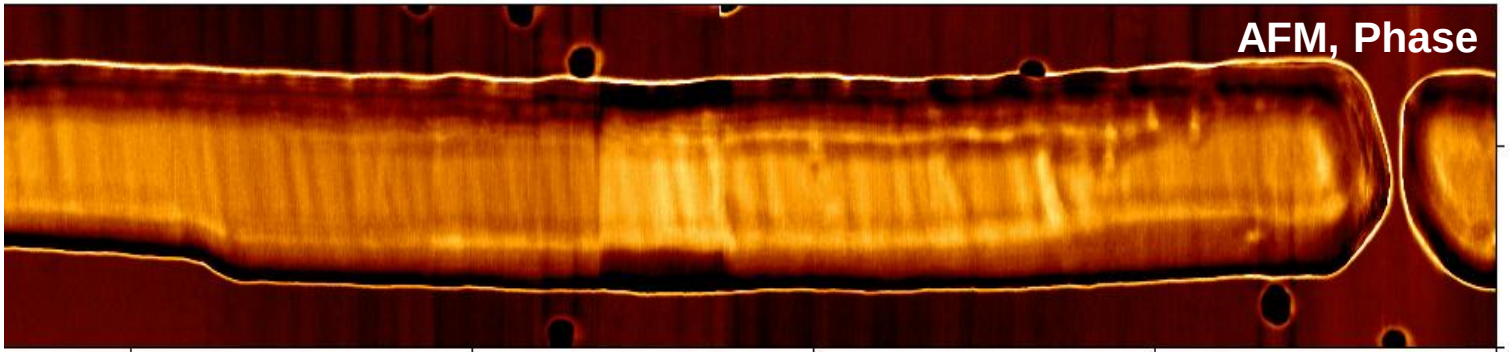
P3HT nanopillars from nano-imprint



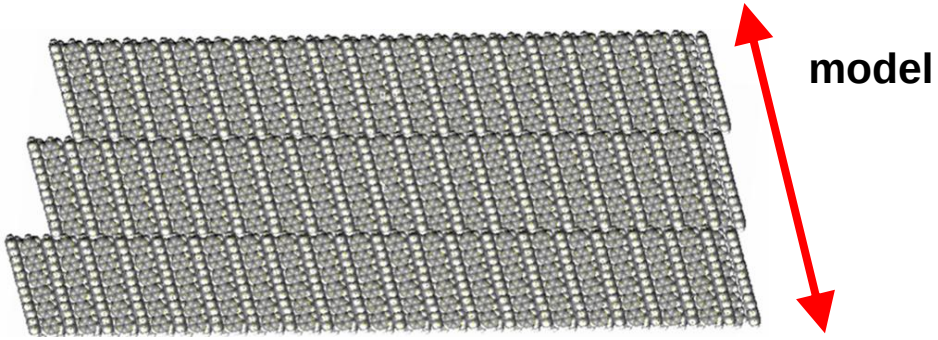


PhD thesis Kirill Bordo (2012)

Organic small molecule nanostructures



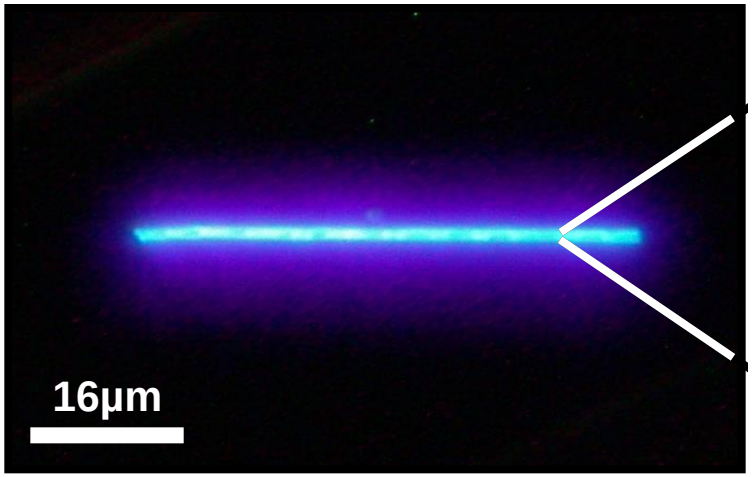
500 nm

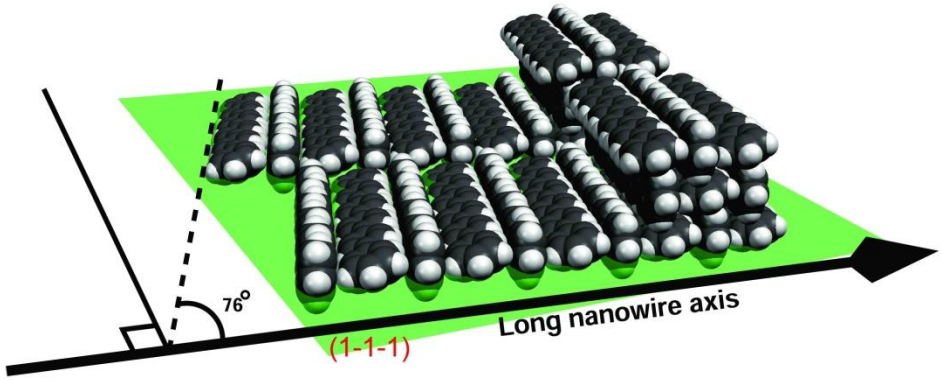


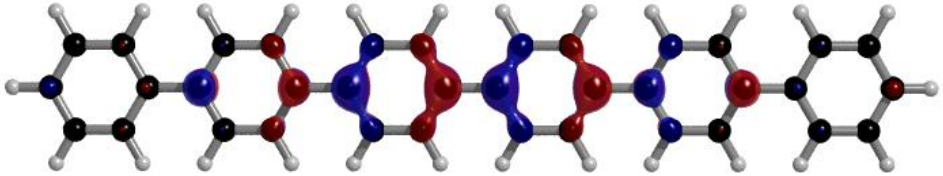
model

Balzer and Rubahn, Surf.Sci., 2004.

Optimum molecular packing





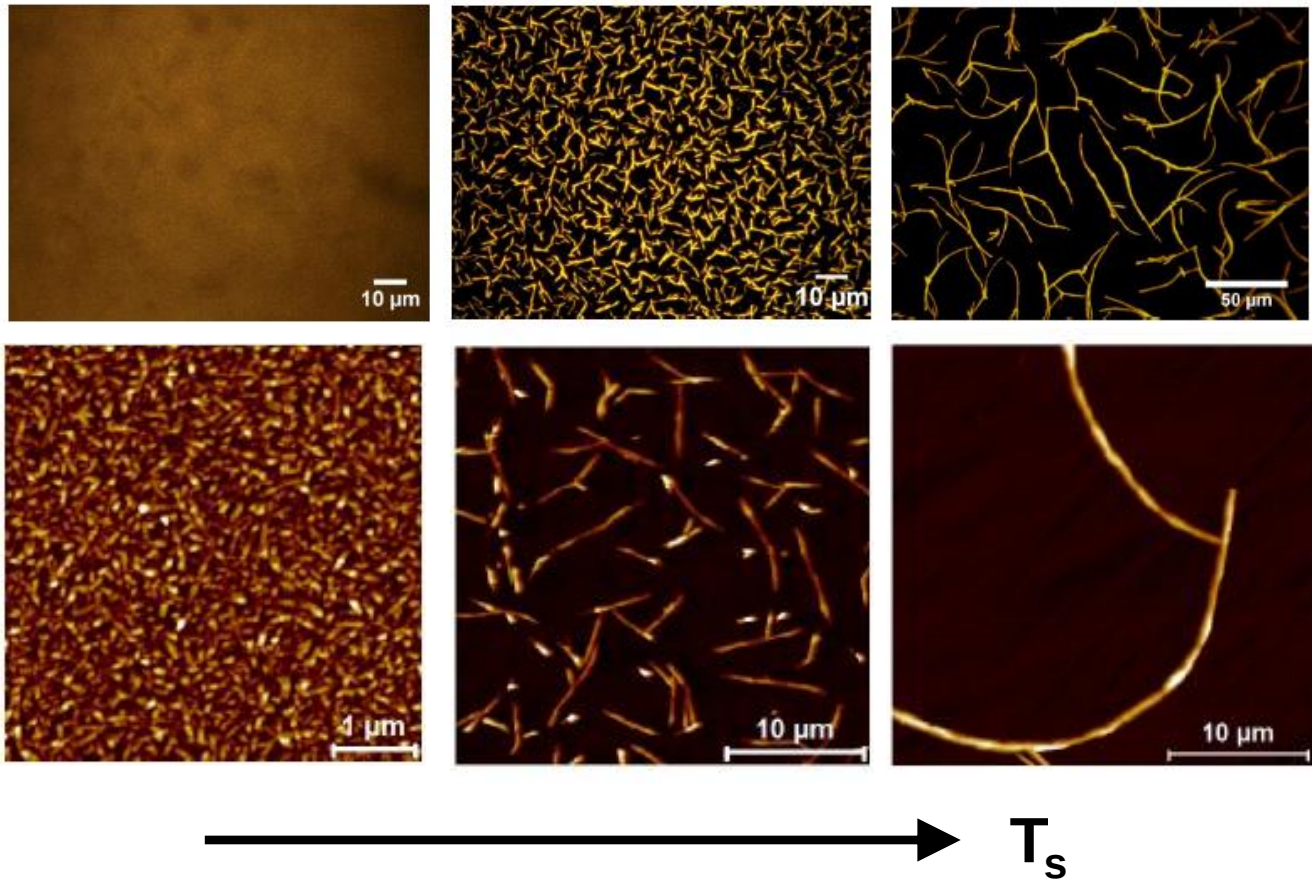


HOMO

The organic nanostructures consist of mutual parallel, flat-lying molecules with optimum electric transport directions

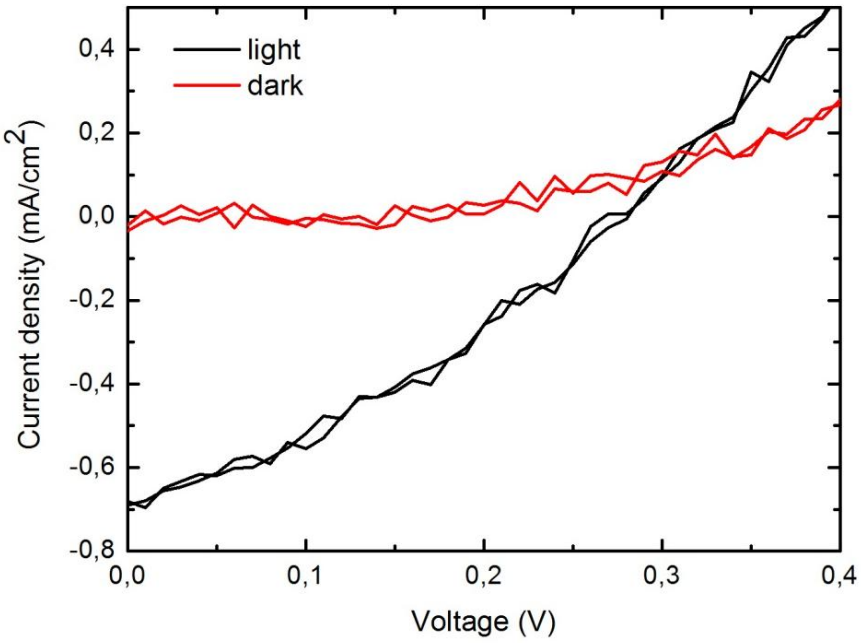
Balzer and Rubahn, Adv.Funct.Mat., 2005

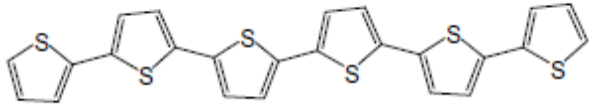
Nano-aggregates for organic solar cells



Morphology control of α-T6 nanostructures on gold electrodes

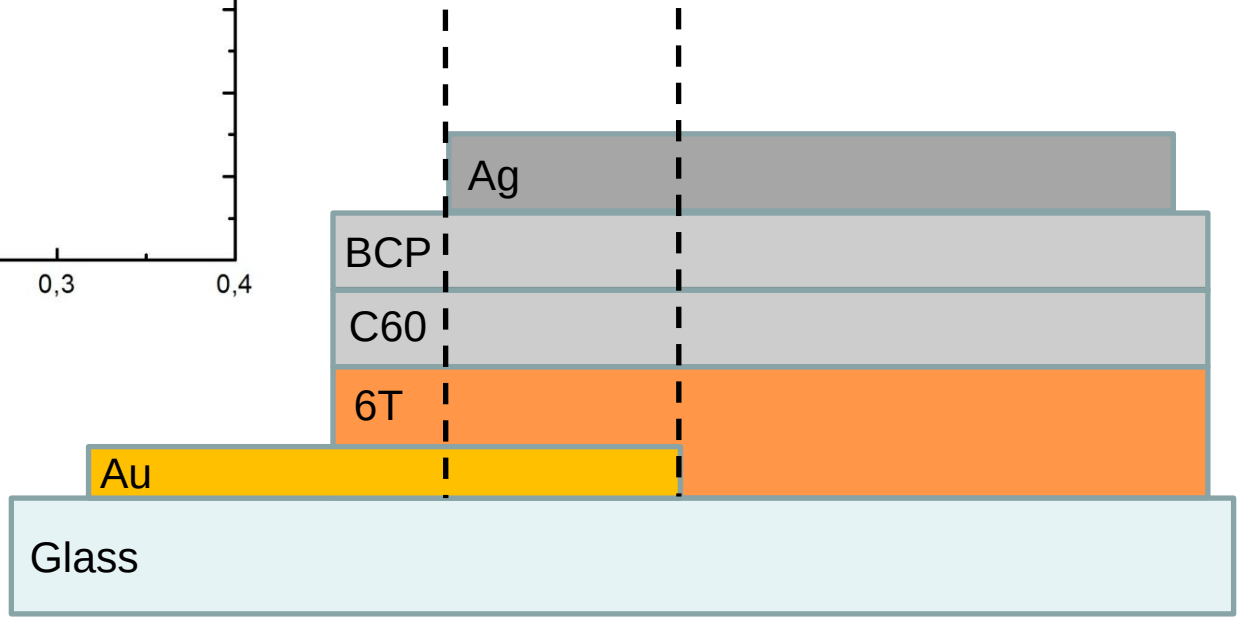
Small molecule Organic Solar Cells



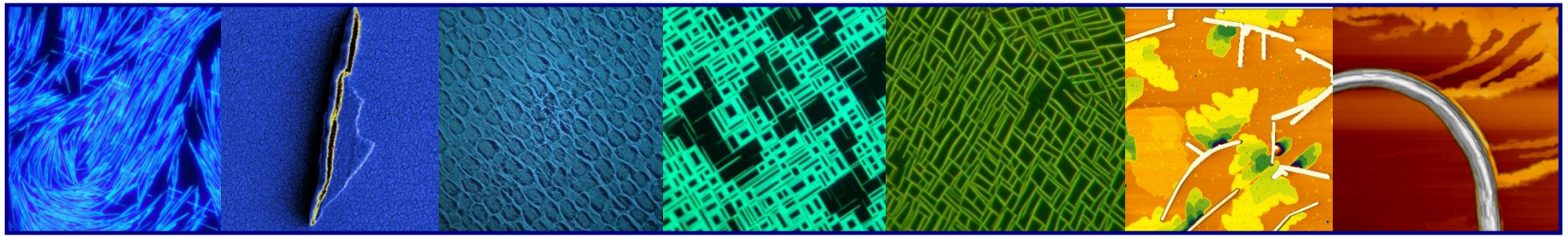


Alpha-sexithiophene (6T)

C_{60}



Note: Semitransparent Top-electrode contact and no interfacial layers



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Master student Yinghui Liu

Bachelor student Mathias Hausladen