

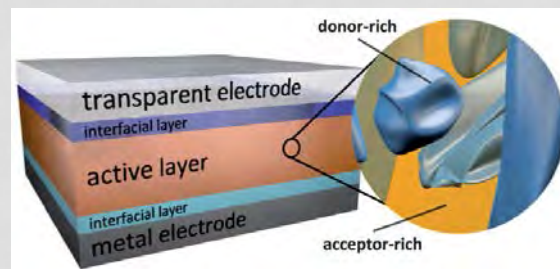
LIGHTING UP THE FUTURE:

LOCAL PRODUCTION OF PRINTED FLEXIBLE SOLAR CELLS

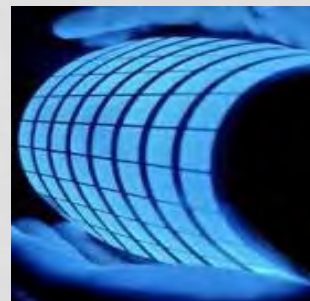
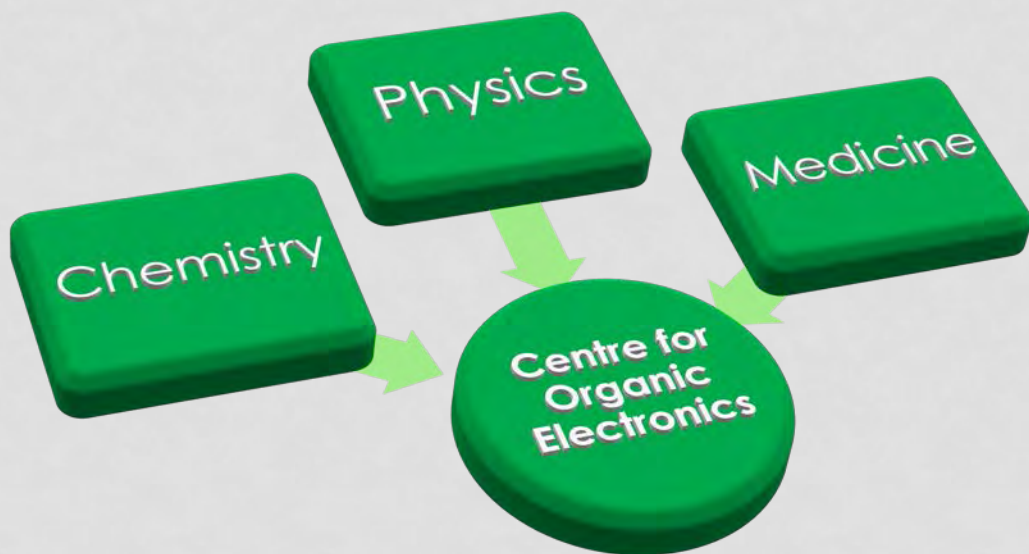
SMART FUTURE CITIES 2015 CONFERENCE

MATT GRIFFITH & CORALIE EPSTEIN

2 OCTOBER 2015



CENTRE FOR ORGANIC ELECTRONICS



OLED lighting

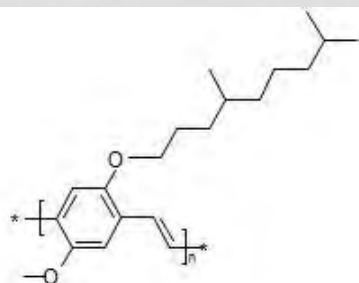


OLED display

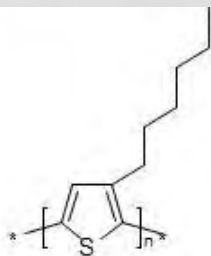


Organic solar cells

SEMICONDUCTING POLYMERS



MEH-PPV



P3HT



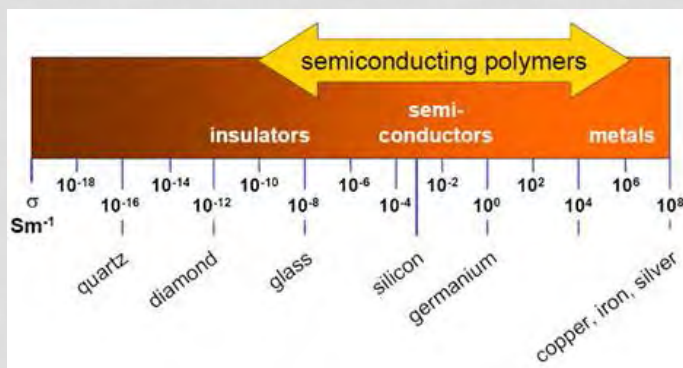
Alan Heeger

Hideki Shirakawa

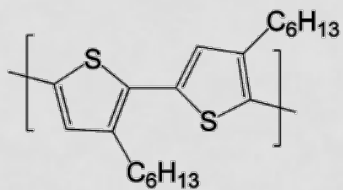


Alan MacDiarmid

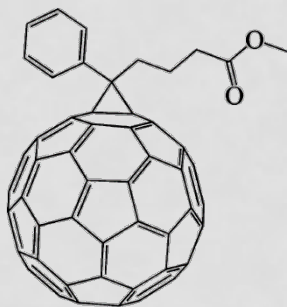
Nobel Prize for Chemistry 2000



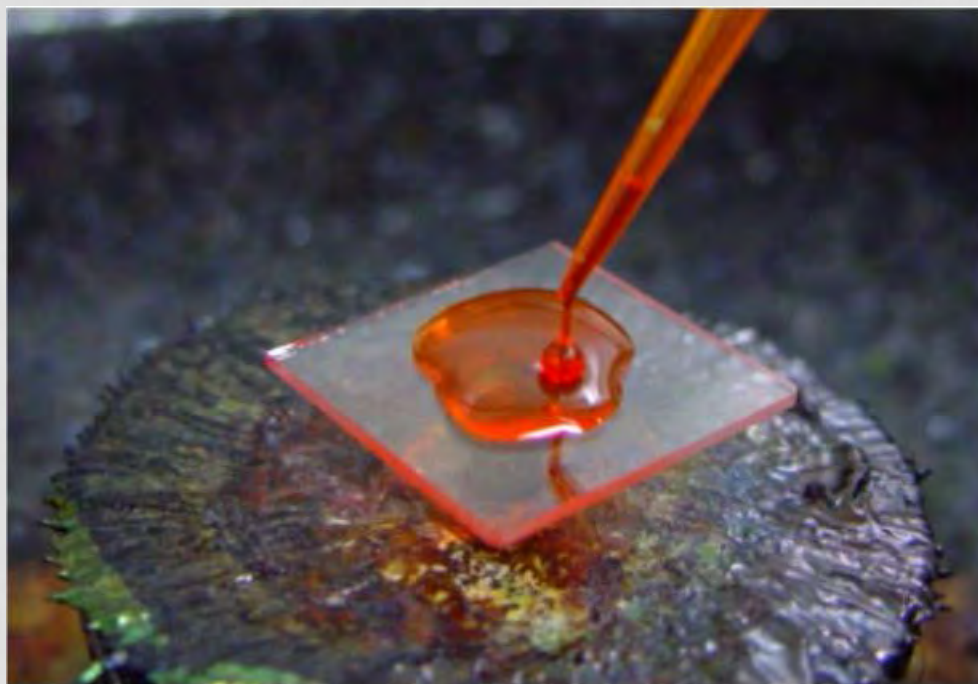
BUILDING ELECTRONIC DEVICES



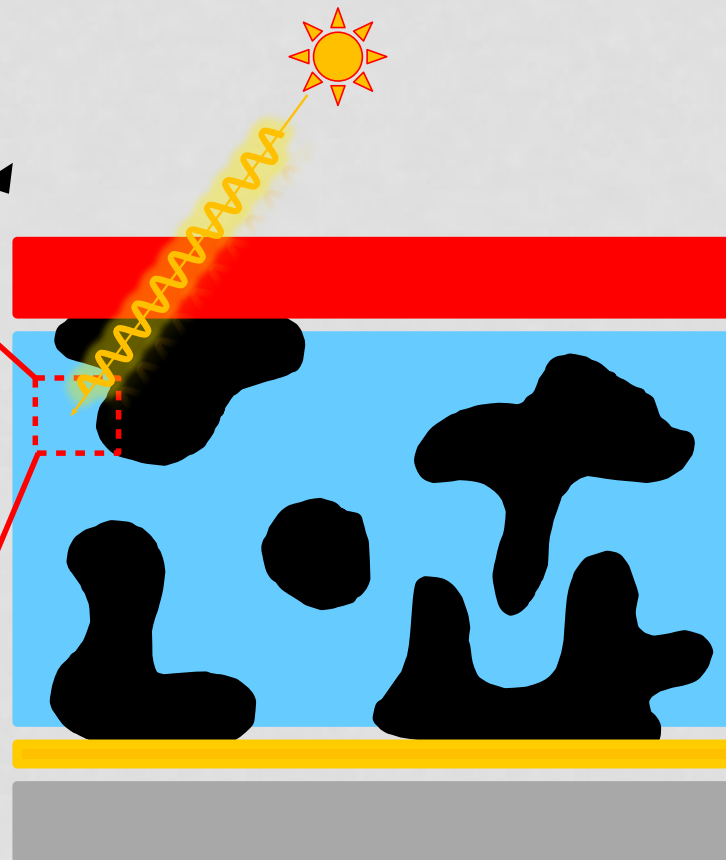
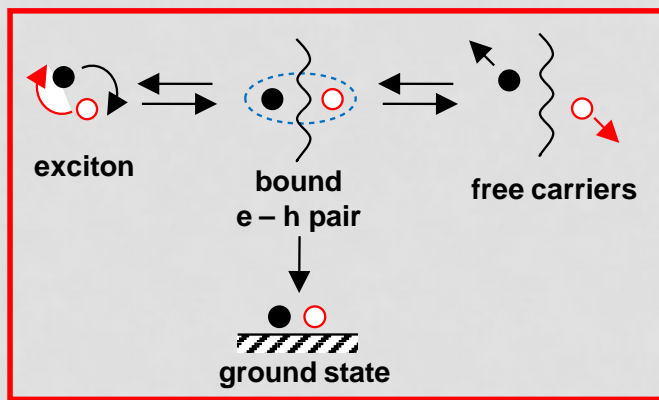
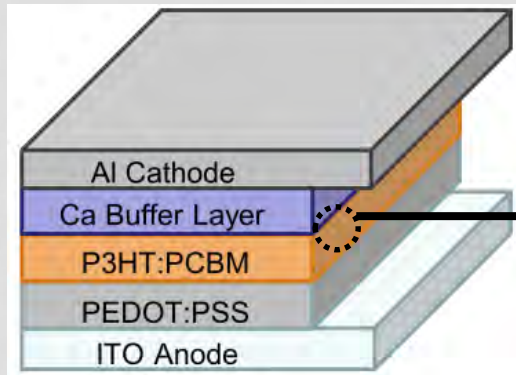
P3HT



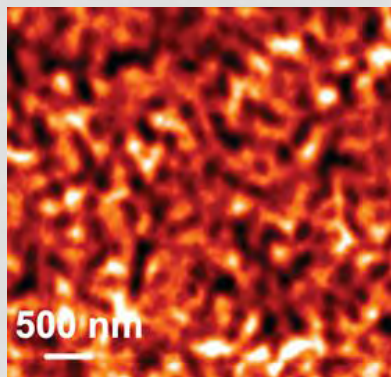
PCBM



ORGANIC PHOTOVOLTAICS: STRUCTURE



CHALLENGES FOR CONVENTIONAL OPV'S



Controlling Nanostructure

- ❑ Few experimental levers
- ❑ Temperature, viscosity
- ❑ No direct control

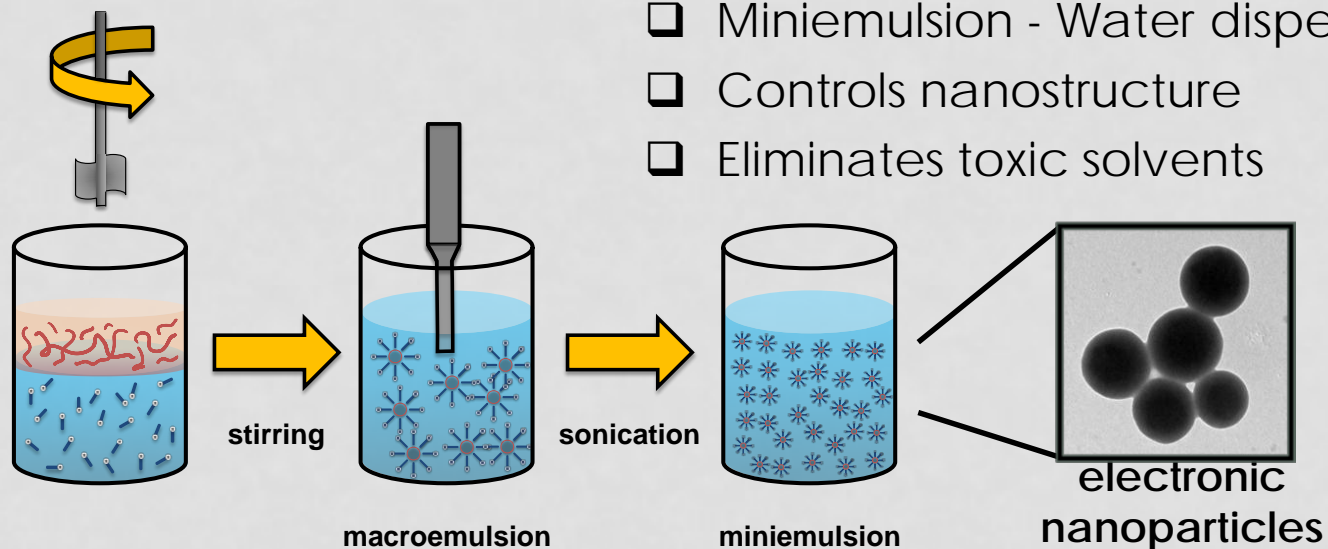


Toxic Solvents

- ❑ Typical solvents
 - ❑ Chlorinated organics
- ❑ Toxic/hazardous/volatile

Challenging for large scale rapid **fabrication** of modules

WATER-BASED SOLAR PAINT



water-based
inks

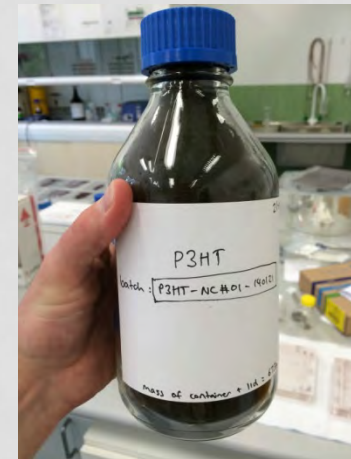
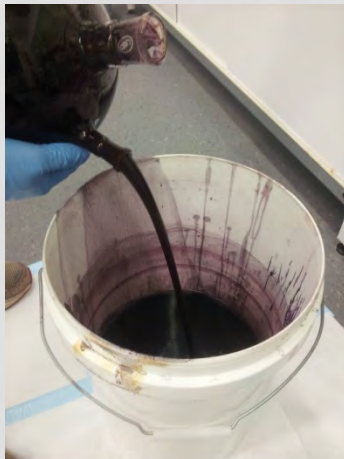
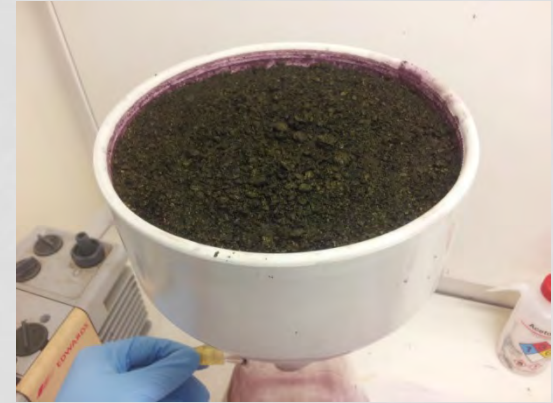


water-based
paints

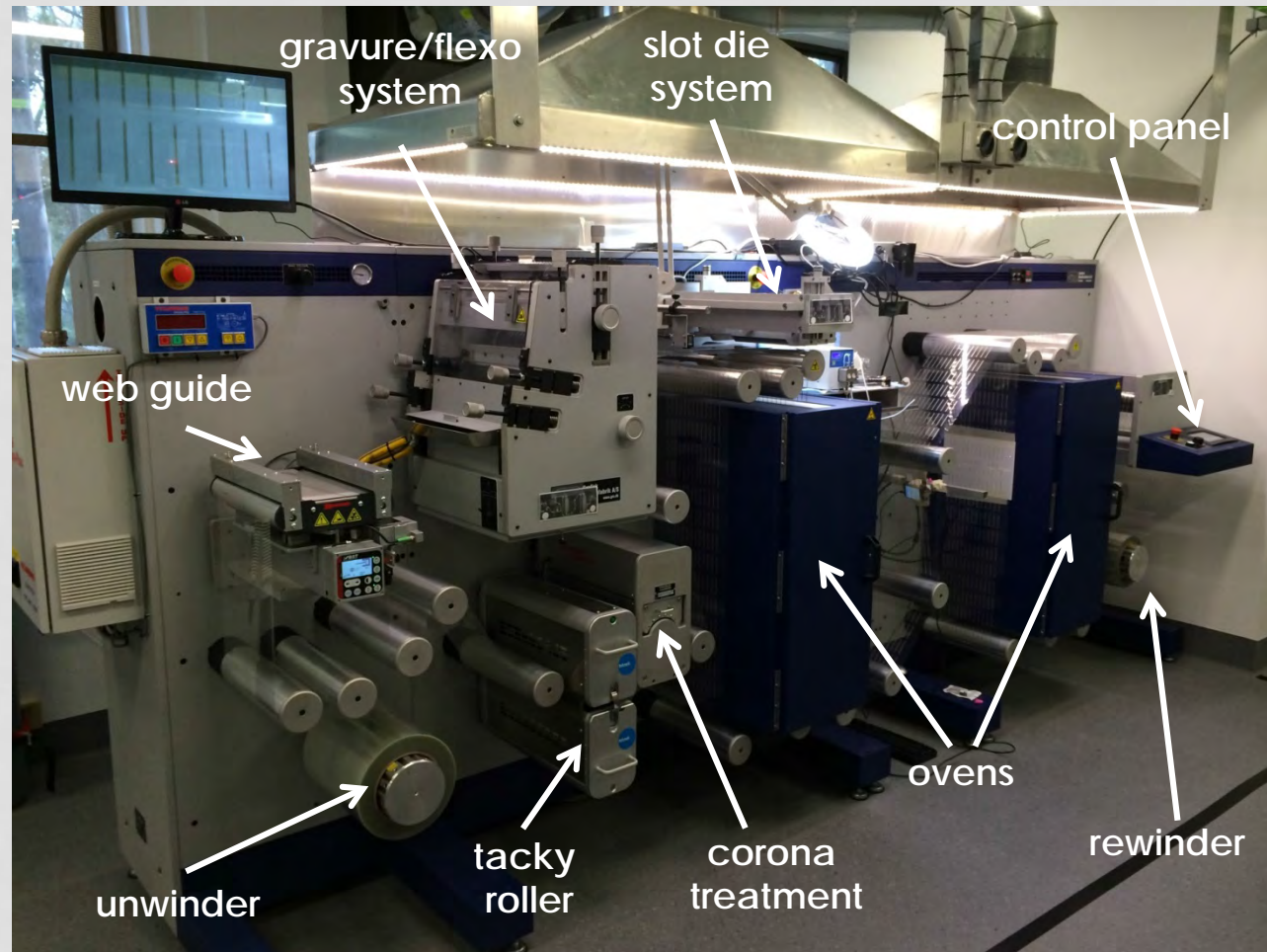


UPSCLAING THE MANUFACTURING

- R2R fabrication consumes a lot of materials!
- **Retail Purchase**
 - P3HT synthesis (2g scale): \$300/g
 - Functionalized Fullerene (2g scale): \$1,000/g
- **In-House Synthesis at COE**
 - P3HT synthesis (100g+ scale): \$9/g
 - Functionalized Fullerene (50g scale): \$21/g

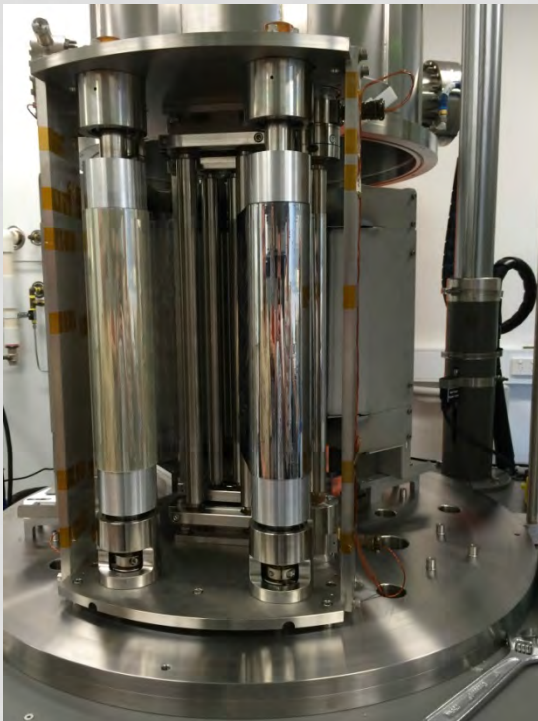


PILOT-SCALE R2R FACILITIES AT COE



PILOT-SCALE R2R FACILITIES AT COE

R2R Sputter Coater



R2R Lamination/Encapsulation



PRINTING AN OPV DEVICE

Transparent electrode

- 1). Conductive grid
- 2). Transport layer

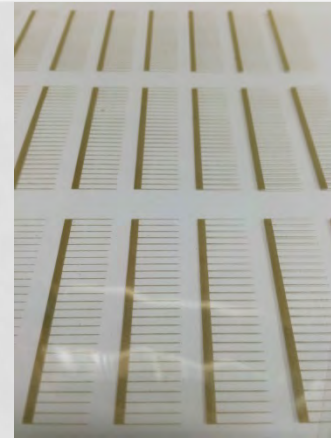
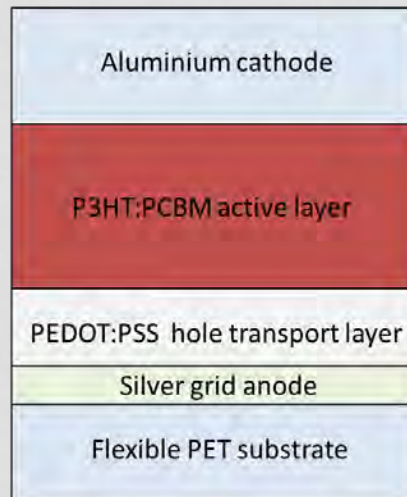
Light Absorbing Layer

- 3). Absorbs light and makes charges

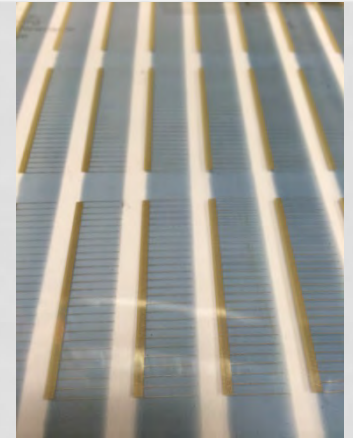
Top electrode

- 4). Metal layer to collect charges

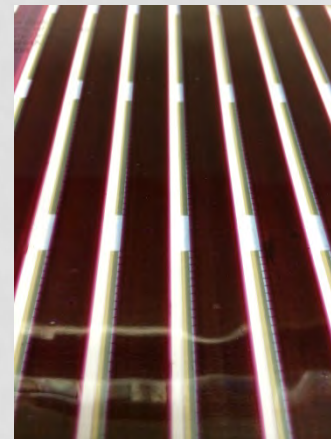
Organic photovoltaic cell



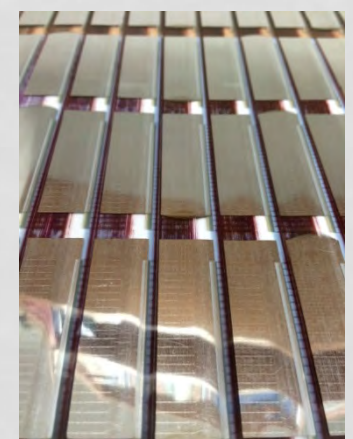
1) Silver electrode



2) Hole transport layer



3) Active layer



4) Aluminium electrode

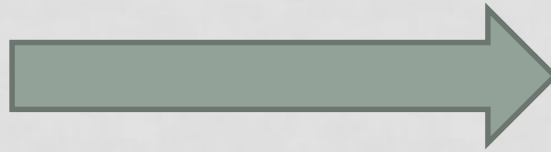
R2R PRINTING OF FLEXIBLE SOLAR CELLS



SOLAR CELL PERFORMANCE

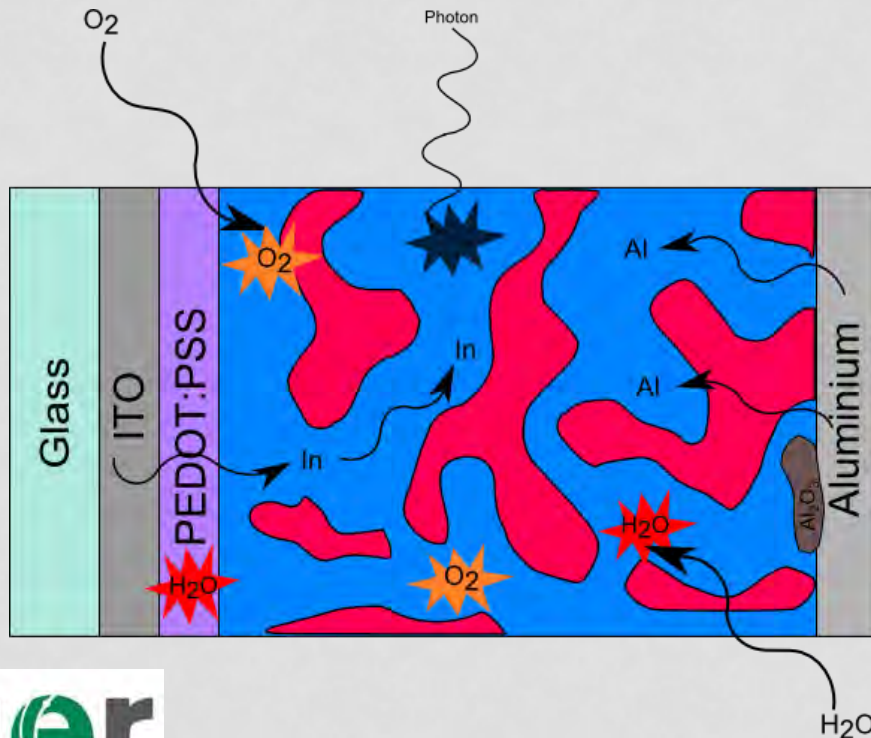
- The performance of an ideal device would not change with time or be affected by outside factors such as temperature and humidity.
- However, it's been shown that the performance of these devices can drop rapidly with time when exposed to the atmosphere.

PRISTINE vs DEGRADED



DEGRADATION PROCESSES

- A major problem with organic solar cells is their short lifetime.



Causes of degradation include:

- Damage to active layer by water and oxygen
- Photo-oxidation of active layer
- Oxidation of aluminium electrode

INVESTIGATING DEGRADATION

- Test the IV characteristics of devices repeatedly over an extended period of time.
- In order to accomplish this an automated testing rig was designed and built which could simultaneously test 8 devices



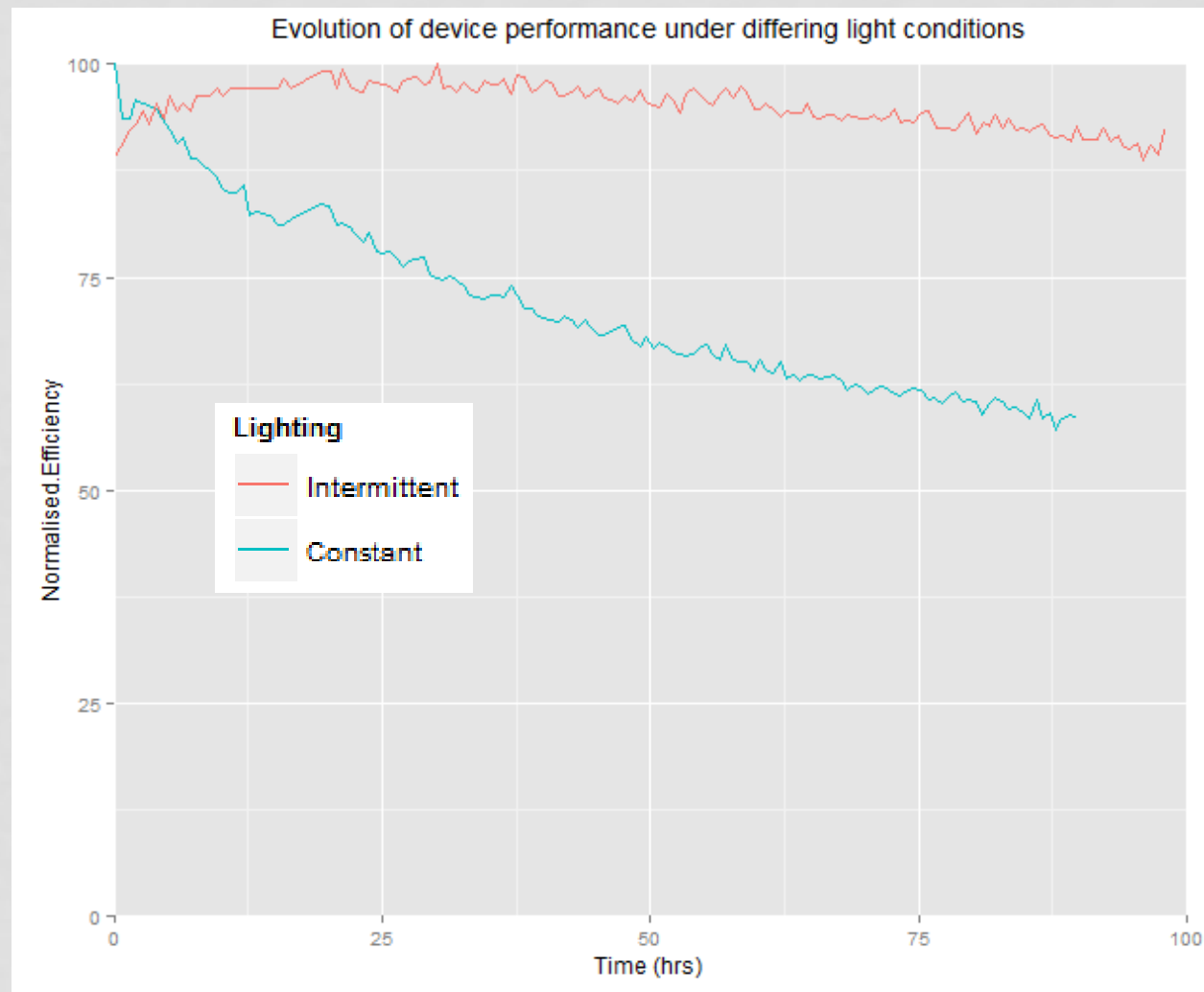
DEGRADATION MEASUREMENTS

- There are two major types of degradation measurements which can be performed:

1. Constant illumination

2. Shelf-life (or Intermittent illumination)

DEGRADATION MEASUREMENTS



ACKNOWLEDGEMENTS

- ***The University of Newcastle Team:***

- ACADEMICS

- Professor Paul Dastoor, Dr Warwick Belcher, Dr Xiaojing Zhou

- POSTDOCTORAL RESEARCHERS

- Dr Ben Vaughan, Dr Nathan Cooling, Dr Krishna Feron, Dr Daniel Elkington, Dr Pankaj Kumar, Dr Nicolas Nicolaidis

- PhD RESEARCHERS

- Natalie Holmes, Matt Barr, Adam Fahy, Sam Legge, Mohammed Al-Mudhaffer, Alaa Al-Ahmad, Mahir Noori, Furqan Almyahi

- UNDERGRADUATE RESEARCHERS

- Matt Willis, Andrew Hart, Acadia Lyons, Josh Hogan

- ***Equipment:***

- Dr John Holdsworth, Dr Kane O'Donnell

- ***Funding:***

- AEL Mining Services Ltd
 - Australian Research Council



SUPPLEMENTARY 1: EFFICIENCY AND COST OF ELECTRICITY

- ❑ Obvious Questions:
 - ❑ What is efficiency?
 - ❑ How long will it last?
- ❑ More important question is:
 - ❑ **What is the cost of the energy?**



- ❑ Efficiency and lifetime are not the only cost factors
- ❑ For solar panel the low materials cost means that the levelised cost of energy (LCOE) is low.

SUPPLEMENTARY 2: COE RESEARCH ON COST OF ELECTRICITY

Traditional Fossil Fuel
(coal fired generation)
\$0.24 / kWh



Photovoltaics
(12 % / 20 yrs silicon solar panels)
\$0.30 / kWh



Current Technology

Solar Paint
(6 % / 6 yrs organic solar coating)
\$0.15 / kWh



Solar Paint
(3 % / 3 yrs organic solar coating)
\$0.47 / kWh



Solar Paint
Materials Cost < \$8/m²

SUPPLEMENTARY 3:

COE RESEARCH - COSTING MODEL

