



天光材料科技公司簡介

ROYENERGY TEK
the inventive solution

成立背景:

- 2014年8月1日成立，總部設於新竹科學園區，從事有機光伏(OPV)材料開發、生產與銷售。
- 實收資本額2.44億元，主要股東上市公司創投。

技術團隊:

- 目前員工總人數約15名，其中博士5人、碩士7人。主要來自化學、化工、材料等背景之專業人才，有超過80%的人員專注在研發與產品應用開發相關的工作。

技術優勢:

- 有機光電材料、元件及制程技術開發
- 有機光電材料生產經驗
- 約50項OPV有機半導體材料專利家族，共計約250篇世界各國專利
- 全球有機光伏(OPV)材料產業的領導者



核心技術與營運模式

核心技術: 世界領先的光活性有機半導體材料、軟性OPV模組優化技術

OPV高效能材料技術

- 材料分子結構設計
- 材料合成及分析技術
- 有機金屬催化聚合反應技術
- 材料量產技術

濕式制程關鍵技術及配方

- 關鍵塗層配方能力與優化技術
- 組件效能及可靠性提升
- 狹縫塗布配方及制程優化
- 網版印刷配方及制程優化

模組優化技術

- 模組電極圖案優化
- 模組封裝技術
- 模組可靠性驗證

營運模式: 提供OPV關鍵材料、模組整體解決方案與技術服務

供應OPV光活性材料

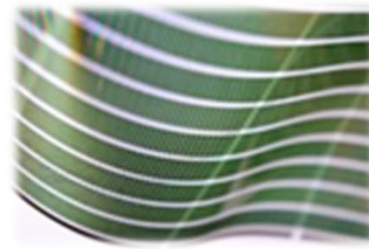
- 材料生產能力
- 主動層配方溶液
- 有機光電池基本性能測試
- 良好的品質管控能力

與模組開發商策略合作

- 客制化塗布配方調整
- 協助導入OPV模組之量產技術
- 協助生產及制程優化
- 提供人員培訓

促成OPV技術商品化

- 替代一次性乾電池
- 可捲曲、可攜式充電裝置
- 結合物聯網(IOT)電子裝置
- 多樣化BIOPV/BAOPV應用



PV2000:

2014年美國NEWPORT認證光電轉換效率: 10.36%

Newport Technology and Application Center
PV Lab
 Accredited Calibration Cert. # 2893.01 Newport Calibration Cert. # 1071

DUT SN: PE12
 Newport Calibration #: 1071
 Manufacturer: Polysol
 Material: OPV
 Temperature Sensor: None
 Environmental conditions at the time of calibration: Temperature: 23 ± 1 °C; Humidity: 45 ± 2%

The above DUT has been tested using the following methods to meet the ISO 17025 Standard by the PV Lab at Newport Corporation. Quoted uncertainties are expanded using a coverage factor of $k = 2$ and expressed with an approximately 95% level of confidence. Measurement of total irradiance is traceable to the World Radiometric Reference (WRR) and all other measurements and uncertainties are traceable to either NIST or CNRC and the International System of Units (SI). This Calibration Certificate is valid for one year from its issue date.

| | | | | | |
|----------------|--------------|-------------------------|-----------------|---------------|-----------------------|
| Efficiency [%] | 10.36 ± 0.22 | V_{oc} [V] | 0.8158 ± 0.0081 | I_{sc} [A] | 0.0006722 ± 0.0000125 |
| P_{max} [mW] | 0.41 ± 0.01 | V_{max} [V] | 0.6541 ± 0.0068 | I_{max} [A] | 0.0006060 ± 0.0000113 |
| FF [%] | 75.6 ± 1.6 | Area [cm ²] | 0.0490 ± 0.0001 | M | 1.004 ± 0.004 |

產品特性優勢:

- 使用不含氯溶劑之配方
- 優異的薄膜塗布品質，不須加溫、在室溫即可進行塗布
- 極佳的材料穩定性，可在大氣下進行薄膜塗布
- 可塗布成厚膜250~400nm，增加吸光量
- 良好的熱穩定，光轉換效率不隨溫度而變化
- 光老化測試 > 20,000小時, 光轉換效率僅衰減10%
- 軟性模組之光轉換效率已可達5%以上




天光材料最新產品—PV5001

PV5001:
2015年認證光電轉換效率: 11.51%

Enlitech Report No.: PVT150602


Test Report



TAF
Testing Laboratory
3038

| | |
|---------------------|--|
| Device Name: | Photovoltaic Device |
| Type: | PV5001 OPV Device |
| Serial No.: | Yu-Hsun Lin_001 |
| Test Date: | 2016 / 06 / 21 |
| Customer: | Keyenergy Tek Incorporation |
| Address: | 2F, No.80, Park Ave.2, Hsinchu Science Park, Hsinchu, Taiwan 30075 |

The test device is measured by the laboratory and the results are given in the content.
The report consists of .J. pages including the cover and is invalid if separated.
The test results of this report are responsible to the device.
The test report should not be reproduced except in full.

Approved by:

Date: 2016.06.21

Enli Tech. Optoelectronic Calibration Lab.
A area, 1F, No. 96, Lake 5th Rd., Kaohsiung, Taiwan, R.O.C

Doc. No. LAB-PV-4.5.10-IC Page 2 of 2 Issue: 2015/02/02

產品特性優勢:

- 已認證世界最高效率，可使用不含氯溶劑之配方
- 可塗布成厚膜250~400nm，增加吸光量

| | | | | | | |
|---------------|---|--------|-----------------|---|-------|----|
| V_{oc} | = | 777.41 | mV | ± | 3.43 | mV |
| I_{sc} | = | 752.09 | uA | ± | 10.08 | uA |
| P_{MPP} | = | 461.67 | uW | ± | 6.47 | uW |
| V_{MPP} | = | 672.00 | mV | | | |
| I_{MPP} | = | 687.02 | uA | | | |
| FF | = | 79.51 | % | | | |
| Efficiency | = | 11.51 | % | | | |
| Aperture area | = | 0.04 | cm ² | | | |

Spectral mismatch correction factor: 1.007





Rayenergy技術發展路線圖

RAYENERGY TEK
the inventive solution

| 年 | 短程目標 | | | 中程目標 | | | 長程目標 |
|-----------|----------------|-------|------|-------------------|------|------|-----------------|
| | 2015 | 2016 | 2017 | 2018 | 2019 | 2020 | 2021~ |
| 目標市場 | 消費電子、攜帶式裝置、IoT | | | BAPV、室內應用、離網電力、車輛 | | | BIPV (屋頂、牆面、玻璃) |
| 器件效率 | 10.3% | 11.5% | 12% | 13% | 14% | 15% | 16-18% |
| 模組效率 | 4-7% | | | 8-11% | | | >12% |
| 模組壽命 (玻璃) | 7-10年 | | | 10-15年 | | | 15-20年 |
| 模組壽命 (軟性) | 3-7年 | | | 8-12年 | | | 13-15年 |



國內產官學研現況

核能研究所為唯一專責
開發OPV量產製程與模
組化技術之國家實驗室

前瞻材料研



產製程開發



技術轉移與產業建立



學

官

產

整合上游學界

創新自主性專利佈局

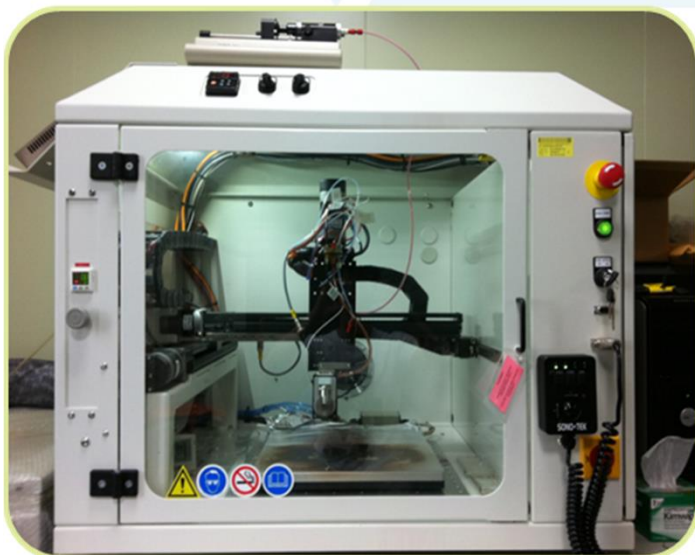
開創國際競爭優勢本土化產業



核能研究所OPV量產技術簡介

Commercial Applications

Ultrasonic Spray



Inkjet Printing



Roll-to-roll



➤ Advantage

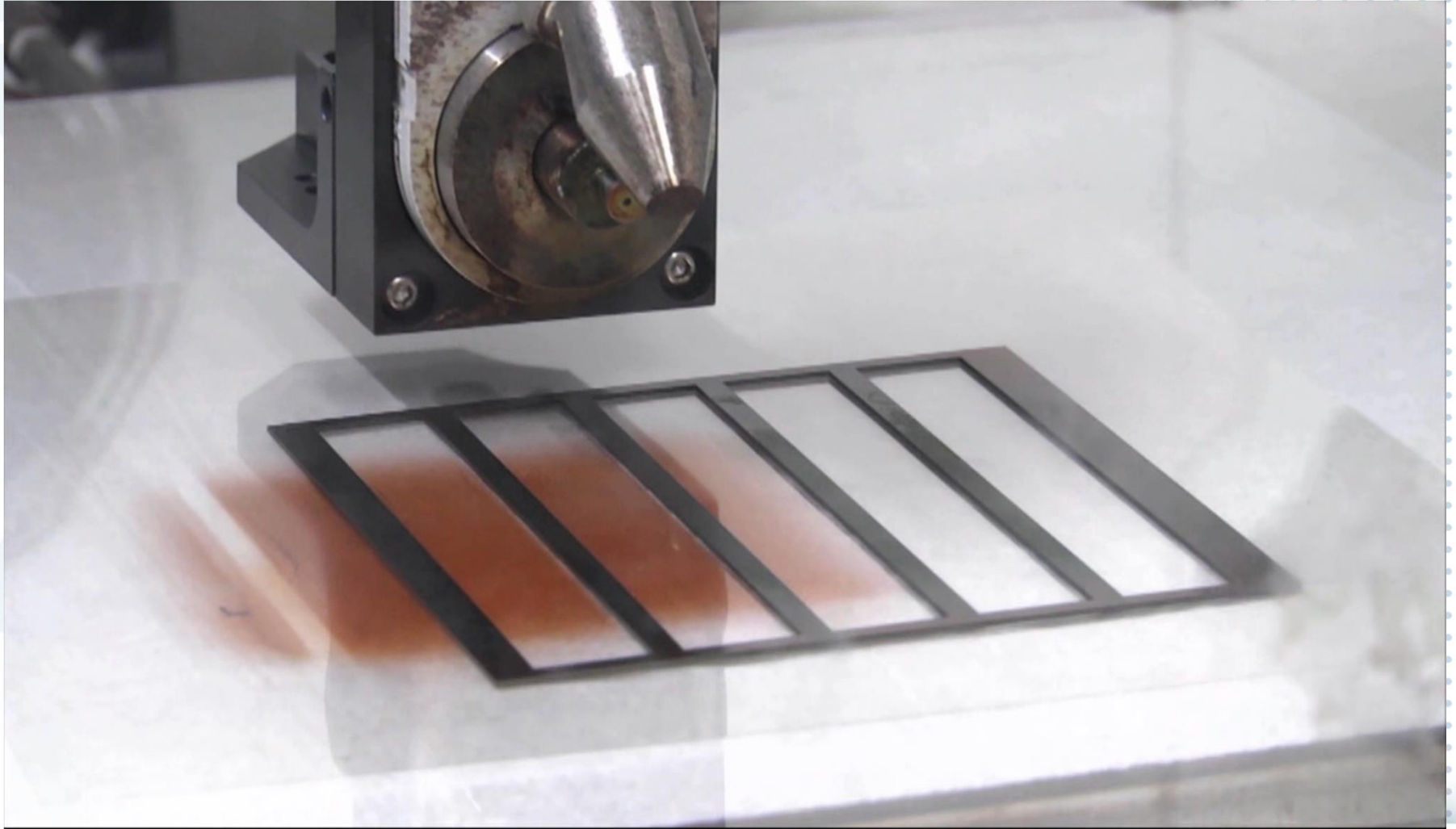
- Low material waste
- Rapid manufacturing
- Large-area capability

➤ Limitation

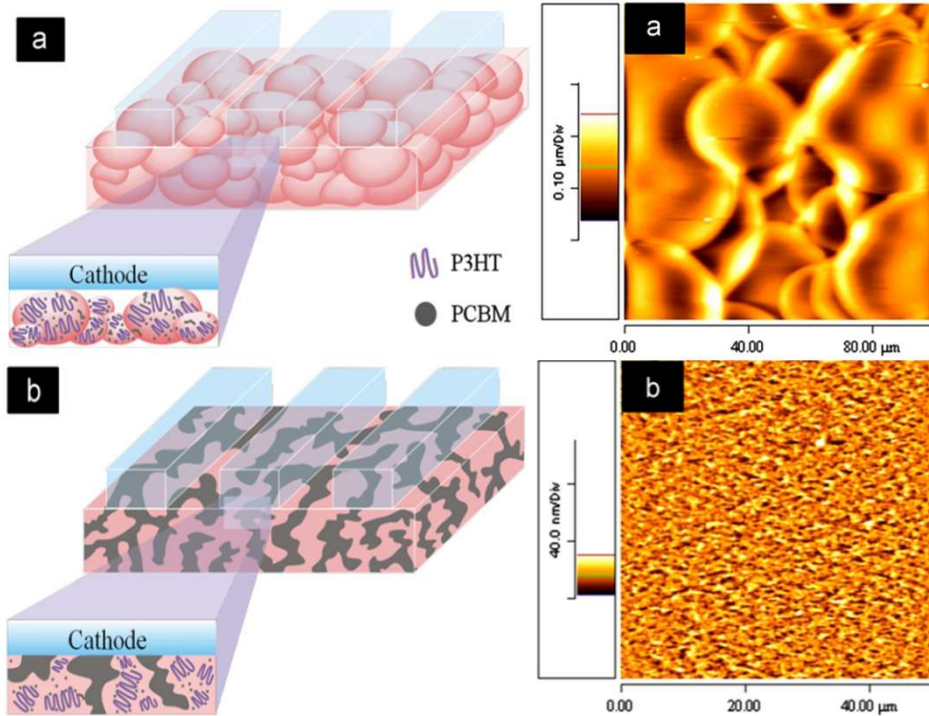
- Film quality



Spray Process Video



Current Achievements by Spray Process



PCE ~ **3.73%**.

(currently reported: 3.35 %)

Solar Energy Materials & Solar Cells, 114, p. 24, 2013

All-spray Process

Spray high-conductive PEDOT:PSS as cathode



PCE ~ **2.9%**

(currently reported: ~ 2.74 %)

Spray silver nanowire as cathode

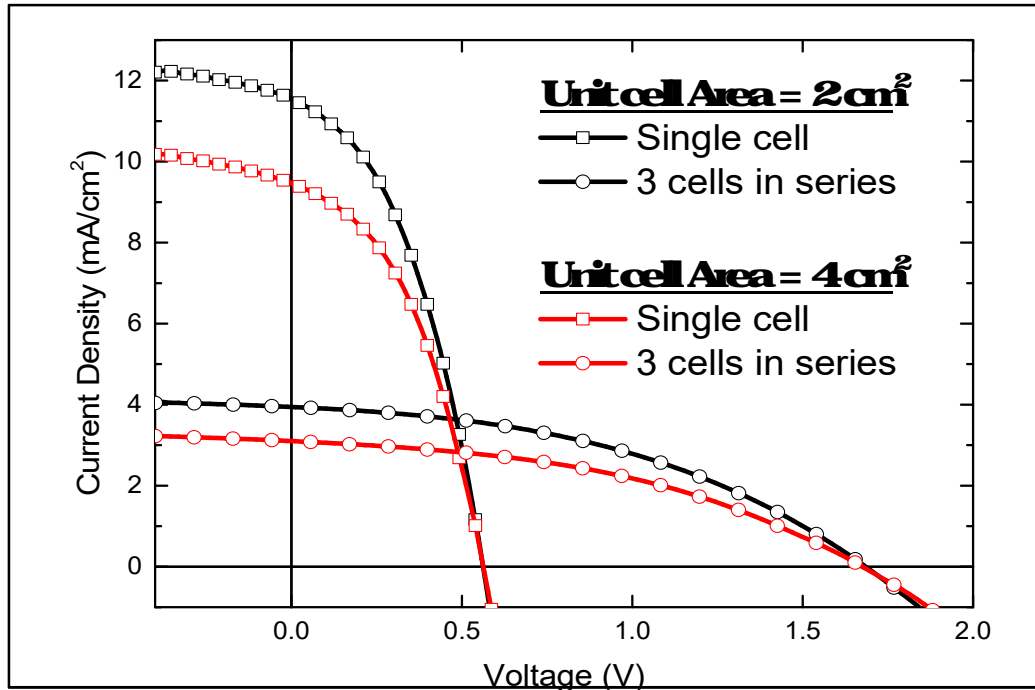
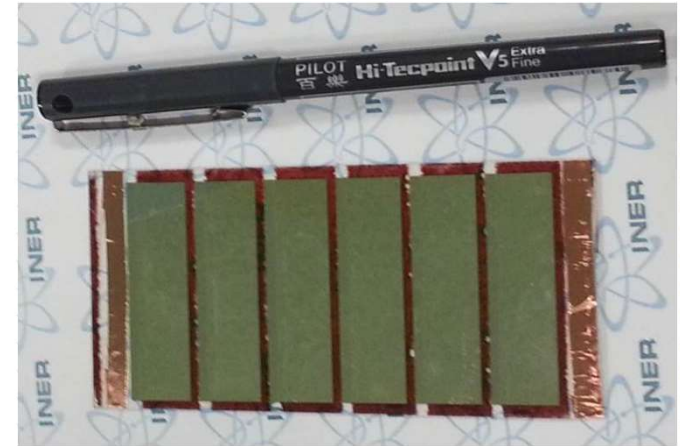
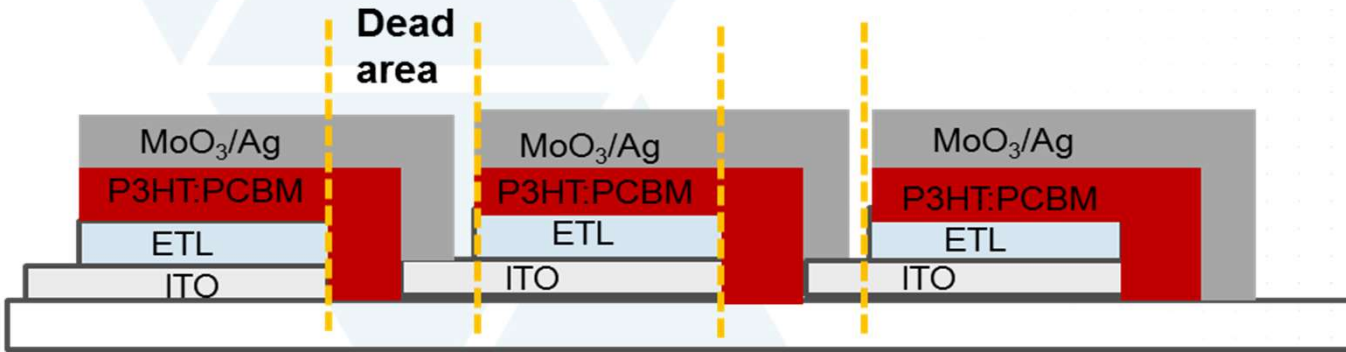


PCE ~ **3.6%**

(currently reported: ~ 2.6%)



Module Fabrication



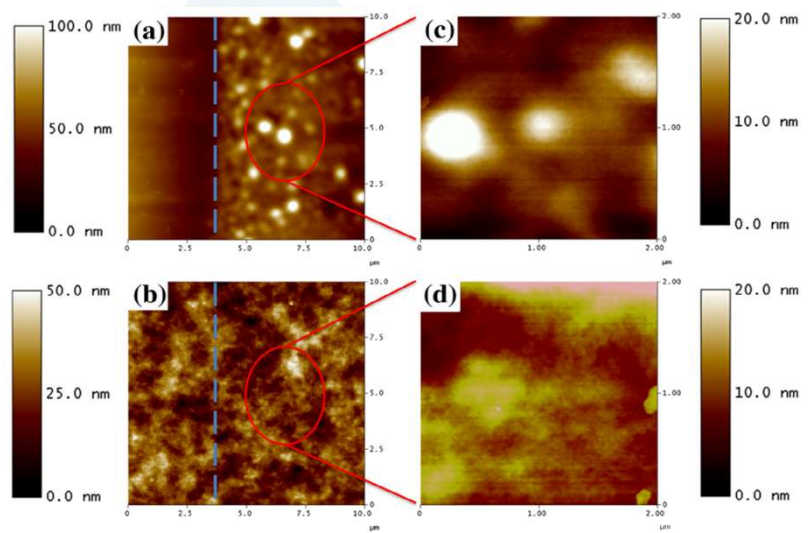
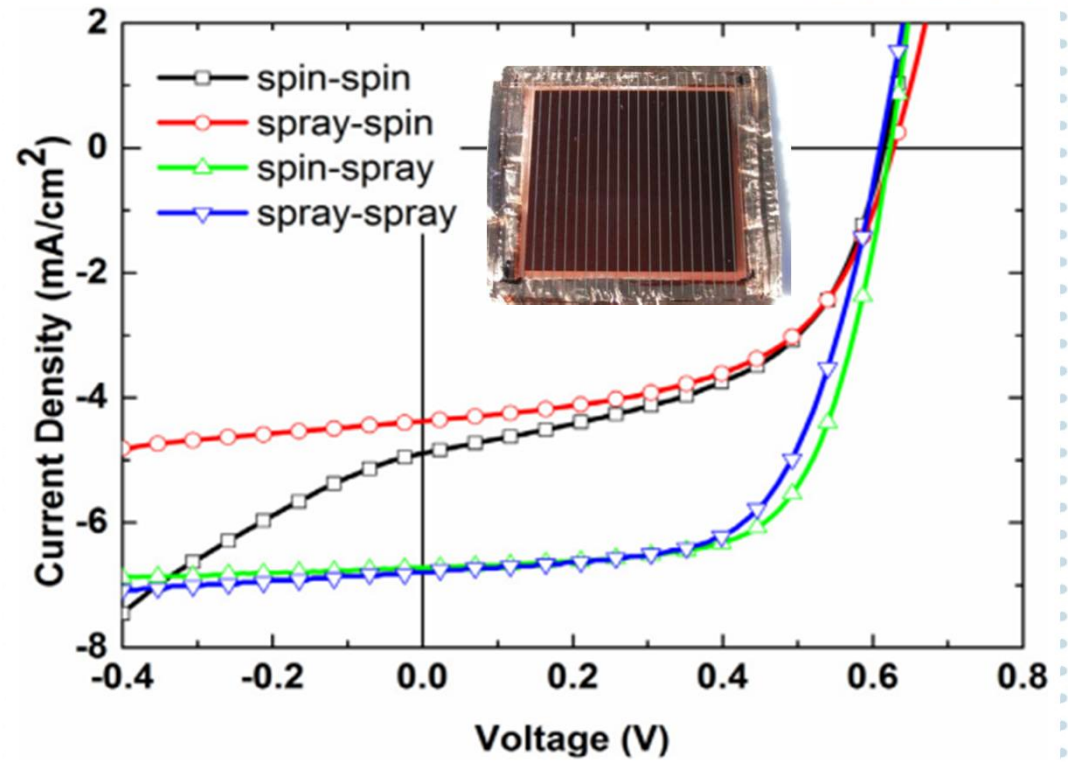
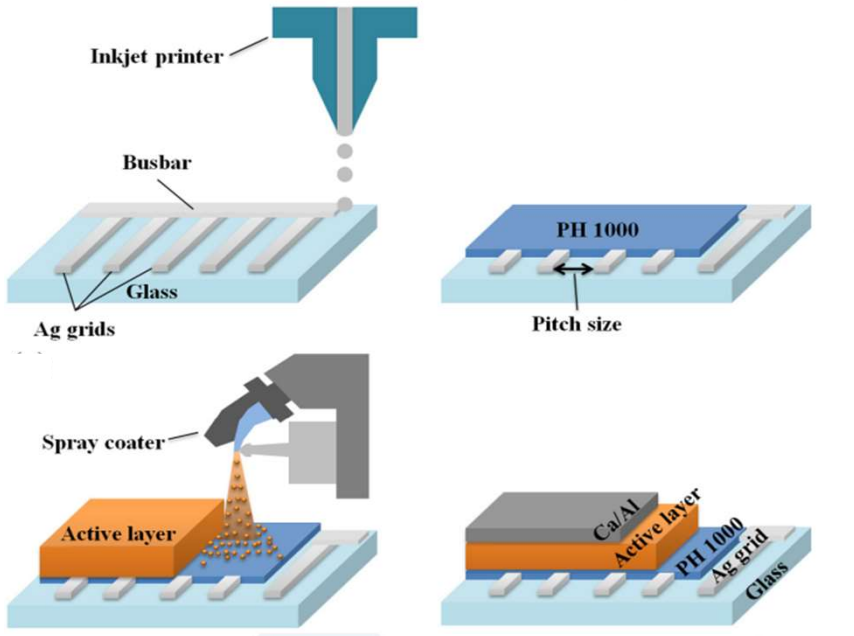
| Unit Cell Area | 2 cm ² | | 4 cm ² | | |
|---------------------------------------|-------------------|-------|-------------------|------|------|
| | Series Number | 1 | 3 | 1 | 3 |
| J _{sc} (mA/cm ²) | | 11.51 | 3.95 | 9.49 | 3.1 |
| V _{oc} (V) | | 0.56 | 1.68 | 0.56 | 1.67 |
| FF (%) | | 42 | 42.1 | 42.7 | 42.1 |
| PCE (%) | | 2.7 | 2.8 | 2.3 | 2.2 |



Inkjet Printing Video



Alternative Transparent Electrode



Performance of the devices used PH1000 as transparent electrode.

| Sample (PH1000-P3HT/ PCBM) | V_{oc} (V) | J_{sc} (mA/ cm^2) | FF | PCE (%) |
|-------------------------------|-----------------|---------------------------|------|------------|
| Spin-spin | 0.62 | 4.90 | 0.52 | 1.58 |
| Spray-spin | 0.63 | 4.67 | 0.55 | 1.61 |
| Spin-spray | 0.62 | 7.00 | 0.66 | 2.86 |
| Spray-spray | 0.61 | 7.14 | 0.62 | 2.70 |

Huang, Org. Electronics (2013)



Roll-to-roll Slot-die Process Video



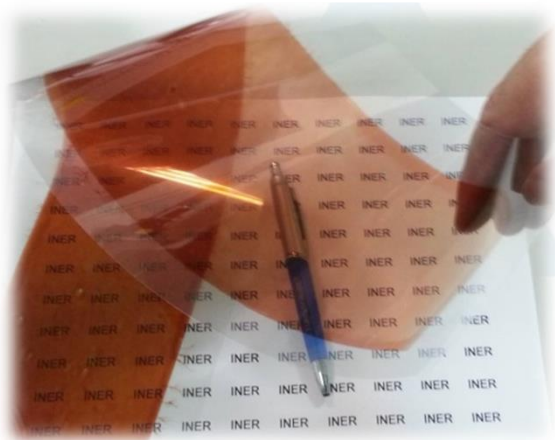


Current Achievements by Slot-die Process

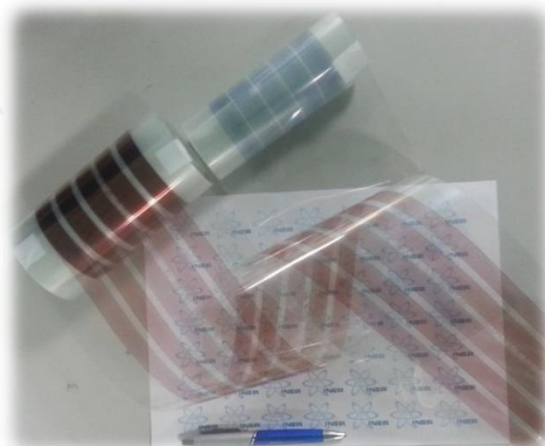
- Inverted P3HT/ICBA PSC: PCE achieves **3.55 %**. (cf. the highest PCE of the same type PSC currently reported: 3.2 %)
- Environmentally-friendly Process: PCE of inverted P3HT/PCBM PSC can be achieved to **2.8 %** using halogen-free solvent **O-xylene**.
- Electron transport layer modification: ETL modification by ZnO:PEIE hybrid layer instead of ZnO layer. PCE enhancement is from **1.83 %** to **2.43%**.

Solar Energy Materials and Solar Cells, 130, p.191, 2014

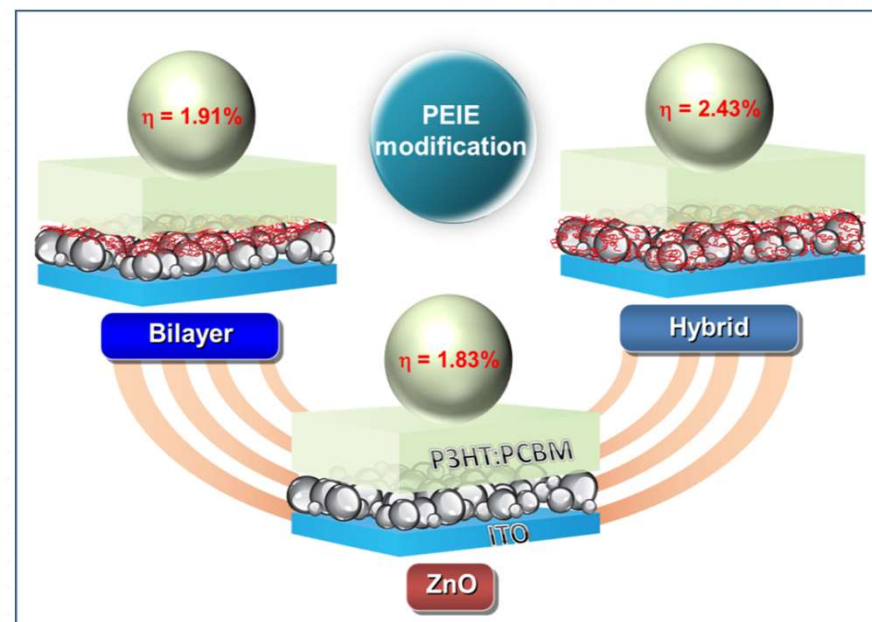
Slot-die coated sample



Slot-die coated Module



ETL modified by PEIE



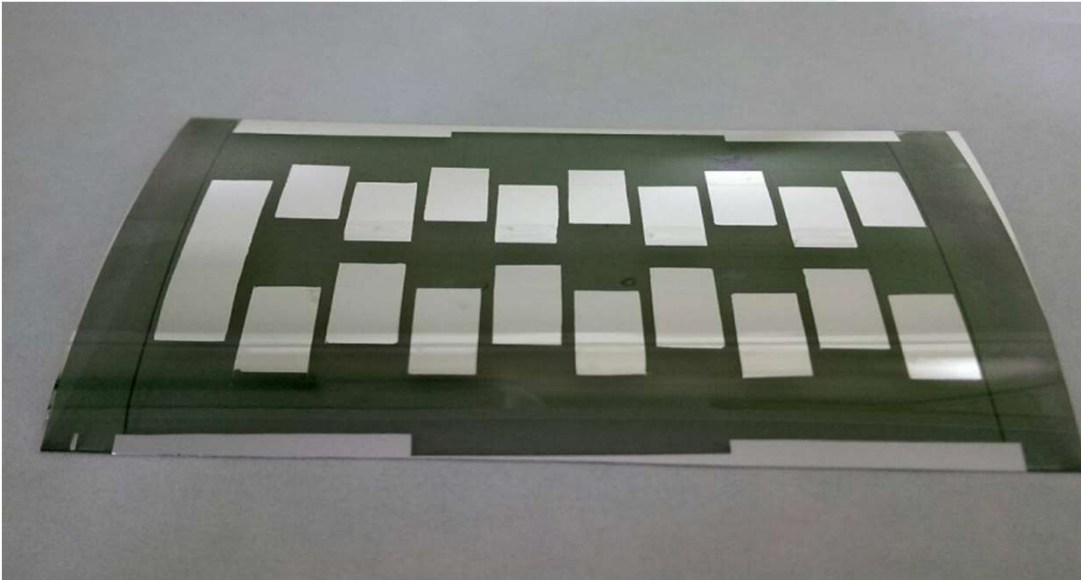
Large-Area Module on PET by R2R Process

PCE : 4.36%

Large-area module:

Unit cell area = $1 \times 1 \text{ cm}^2$

Series and parallel connection of 20 cells

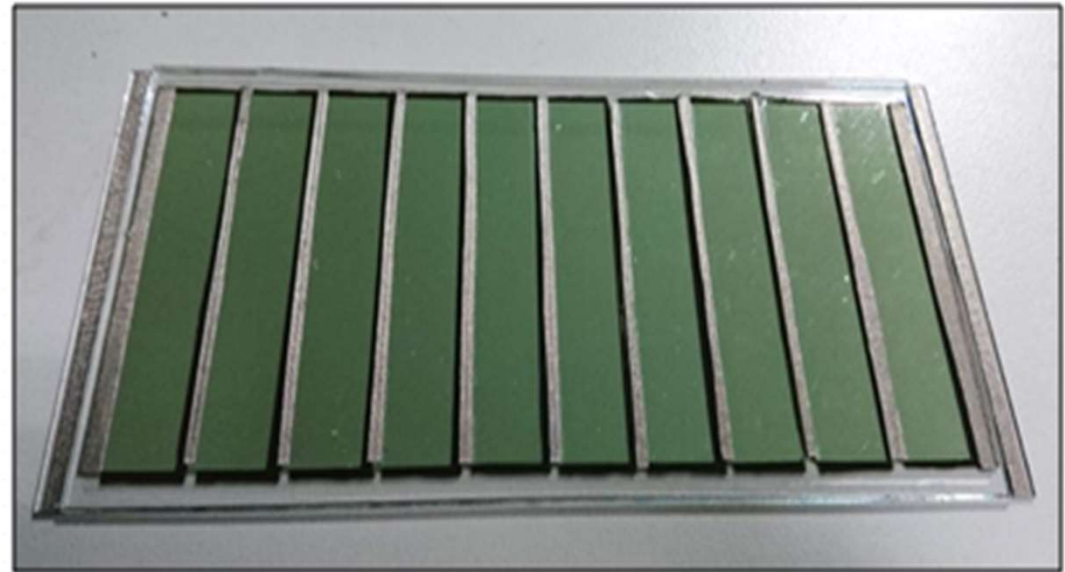


PCE : 5.6%

Large-area module:

Unit cell area = $1 \times 6 \text{ cm}^2$

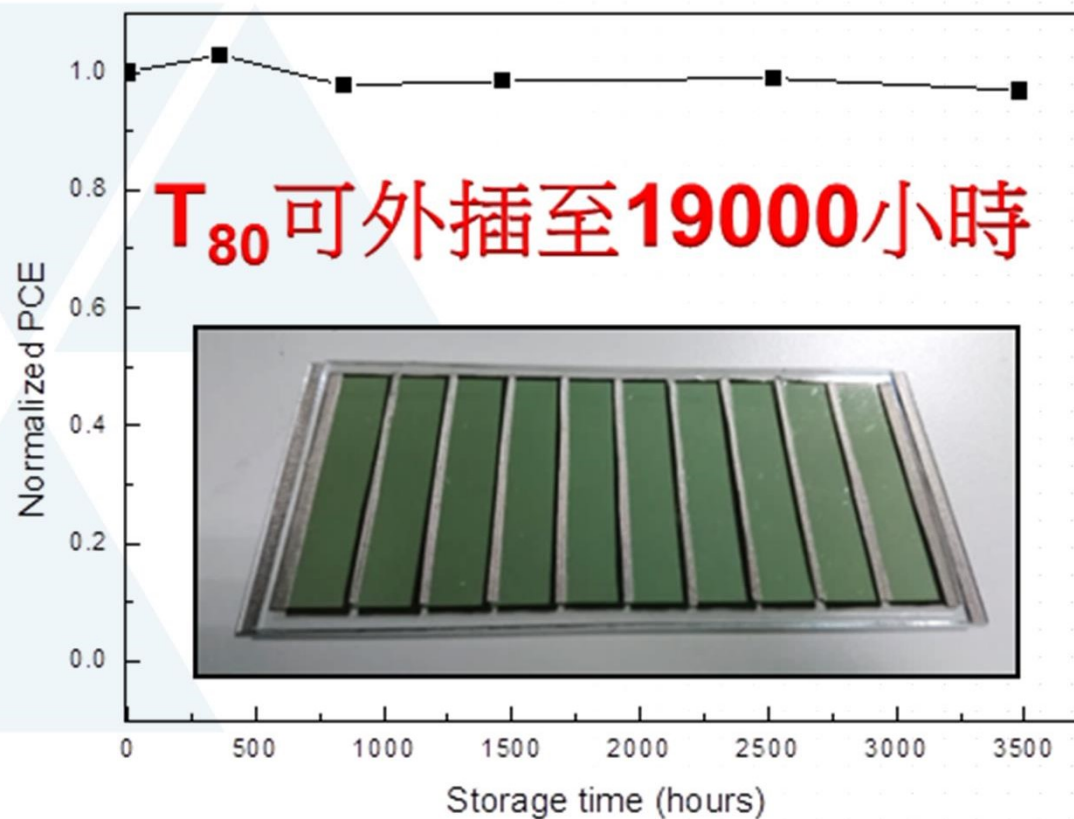
Series connection of 10 cells



模組總面積: $\sim 100 \text{ cm}^2$



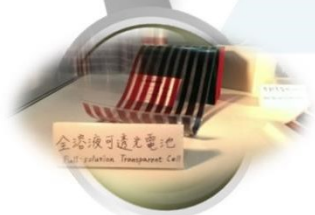
模組壽命 $T_{80} > 12000$ hr



2013-PV Taiwan

靜態設計模型展品

動態展示



以模組驅動風扇

全溶液透光電池

軟性串聯模組

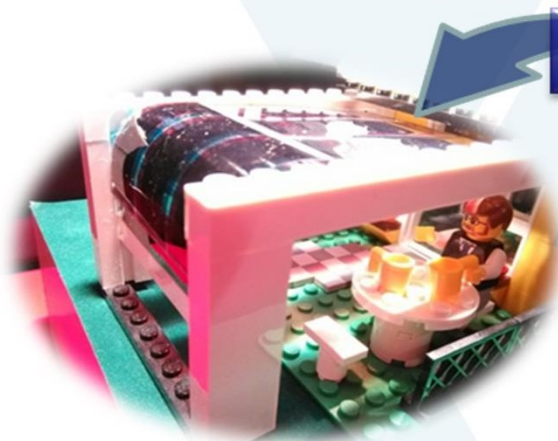
卷對卷製程模組



2013-PV Taiwan

結合太陽能電池概念屋

軟性發電隔熱採光罩



陽光綠化屋頂



透明發電節能窗





2014 International Invention Exhibition

Pittsburgh-Gold Medal



Geneva-Silver Medal



Bluetooth Solar Keyboard



核研所OPV團隊開發之 Mini-Module

OPV module ←



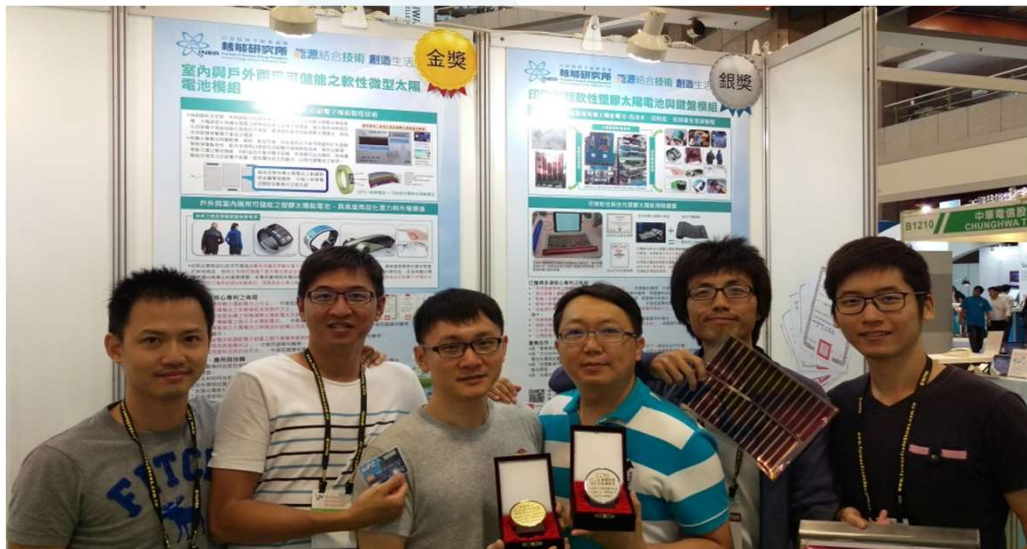
Electronic paper as display



取代乾電池

2015年台北國際發明展金牌獎

2016年台北國際發明展銀牌獎



OPV Market and Applications - Entry

Small/Entry market segments

1 Indoor applications



efficient indoor



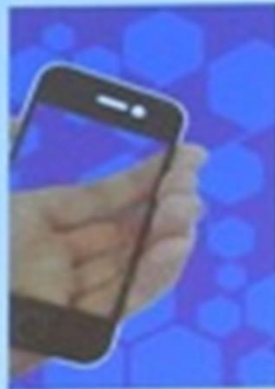
tailor made



bendable & easy to laminate



Picture with courtesy of Belectric OPV



2 Mobile applications



low weight



bendable & easy to laminate



tailor made



Pictures with courtesy of Belectric OPV



OPV Market and Applications - Large

Large market segments

3 Building-integrated PV (BIPV)



low shadow sensitivity



choice of colors



efficient under diffuse light



Pictures with courtesy of Belectric OPV

4 Light-weight rooftop



low weight



bendable & easy to laminate



roll-to-roll printable



Pictures with courtesy of CSEM

MERCK

Merck presentation, EU-PVSEC 2016, Germany.



結語

- OPV 具備輕薄、可撓軟性及透光等特色，其利用非真空、溶液印刷塗佈方式製作，具有環保低碳、低成本，及容易製造等優勢。
- 其應用層面廣泛，從戶外發電至室內弱光下均可應用，相較於傳統無機太陽電池擁有獨特利基市場。
- 目前產業化之關鍵在於模組量產製程技術精進與壽命之提升，相信不久之未來相關產業將蓬勃發展。
- 且其現有平面異質接合模組核心製程技術亦可做為未來鈣鈦礦太陽電池之量產關鍵，也可與鈣鈦礦電池結合成疊層結構，運用面向可多方拓展。政府須持續支持將 OPV 產業定為國家遠程目標發展。



感謝:

核能研究所 OPV團隊:

黃裕清、查厚錦、顏嘉德、宋運明、
莊智閔等博士及 鍾翠芸、余政霖、陳
政佑等其他成員之貢獻努力

及

陳長盈組長與林金福副所長指導與支持





敬請批評與指教

