

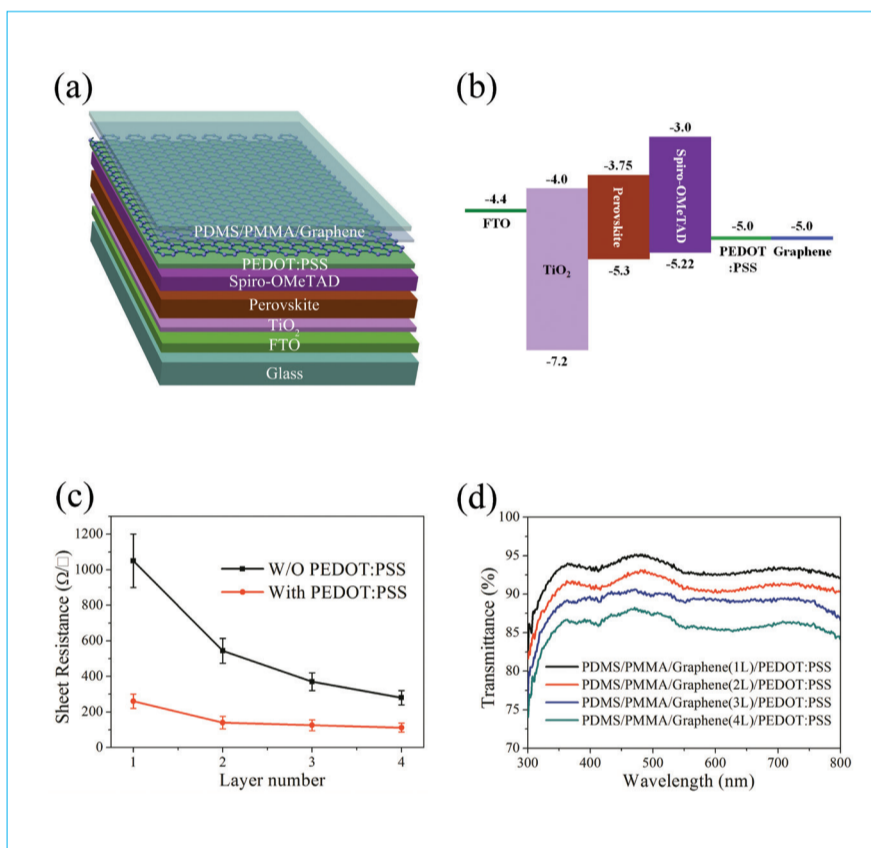
# 高效石墨烯鈣鈦礦半透明太陽能電池

## Semitransparent Perovskite Solar Cells with Graphene Electrodes

製造工序簡單、可兩邊吸光，而且能源轉換效率高  
Simple Fabrication, both side light absorption, and with high power conversion efficiencies

理大科研人首次利用石墨烯成功製備出半透明鈣鈦礦太陽能電池，其能源轉換效率高，而且成本低廉。首先，在粘合鈣鈦礦吸光層和石墨烯的過程中，在石墨烯上塗上一薄層導電聚合物，可以顯著增加其導電性。其次，使用多層的石墨烯為電極，其面電阻可以顯著降低，也可以維持電極的高透明度。最後，透過優化面層石墨烯電極與附於鈣鈦礦層的空穴傳輸層的接觸，進一步地提升效能。

由於製作程序簡單，加上石墨烯卓越的機械柔軟性特質，半透明鈣鈦礦太陽能電池可採用印刷或捲對捲的方法而進行大量生產。



器件結構和能帶結構示意圖，及其石墨烯電極的面電阻和透過率  
Schematic diagram and band structure of a semitransparent perovskite solar cell, and the sheet resistance and UV-Vis transmittance spectra of graphene films.

PolyU researcher has developed the first-ever made semitransparent perovskite solar cells with graphene as electrode. With simple processing techniques, solar cells with high power conversion efficiencies can be fabricated at low cost. Firstly, the conductivity of graphene was dramatically improved by coating a thin layer of conductive polymer during the lamination process of graphene and perovskite layer. Secondly, multi-layer graphene is used as electrodes to further improve the efficiency of power conversion. The sheet resistance of the electrode could be further reduced while maintaining the high transparency of the electrodes. Lastly, the performance is further optimized by improving the contact between the top graphene electrodes and the hole transport layer on the perovskite films.

Because of the excellent mechanical flexibility of graphene and the convenient preparation of the devices, this invention can be used for the mass production of the semitransparent perovskite solar cells with printing or roll to roll process.

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### 特色與優點

- 半透明，因而可以集成到建築上
- 透過率可以調控
- 可兩面吸光
- 能源轉換效率高達12%
- 製作過程簡單，成本低

### 應用

將半透明太陽能電池用於建築物外，取代傳統的建築材料，如：外牆、遮陰處、天窗、窗戶和屋頂等。

### 獎項

加拿大國際發明創新比賽2016 - 金獎 (2016年8月)



石墨烯鈣鈦礦半透明太陽能電池  
Semitransparent perovskite solar cell with graphene top electrodes

Top electrode	Illumination side	$V_{oc}$ (V)	$J_{sc}$ (mA/cm <sup>2</sup> )	FF (%)	PCE (%)	Average PCE (%)
Au	FTO	0.985	19.80	73.58	14.35	13.62±1.00
Graphene (1L)	FTO	0.910	17.46	57.8	9.18	8.65±0.45
Graphene	Graphene	0.905	16.35	59.07	8.74	8.38±0.43
Graphene (2L)	FTO	0.960	19.17	67.22	12.37	12.02±0.32
Graphene	Graphene	0.945	17.75	71.72	12.03	11.65±0.35
Graphene (3L)	FTO	0.940	18.54	65.70	11.45	10.95±0.46
Graphene	Graphene	0.950	17.04	67.58	10.94	10.37±0.52
Graphene (4L)	FTO	0.950	18.05	65.72	11.27	10.68±0.57
Graphene	Graphene	0.930	16.01	68.37	10.18	9.27±0.83

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### Special Features and Advantages

- Semitransparent enables to be used for buildings
- Transparency can be controlled
- Can absorb light from both sides
- High power conversion efficiency ~ 12%
- Easy fabrication and low cost

### Applications

Semitransparent solar cell technology can be integrated into the building design, replacing conventional building materials. Such as, facades, shelters, louver, windows and rooftops, etc.

### Award

Gold Medal, iCAN 2016 International Invention Innovation Competition in Canada, Canada (Aug 2016)

