Perovskite Solar Technology

鈣鈦礦太陽光電技術

前創科技 廖學中

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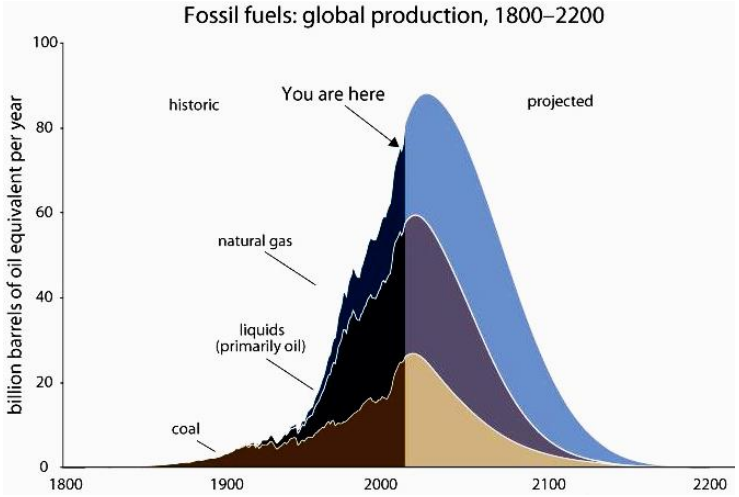
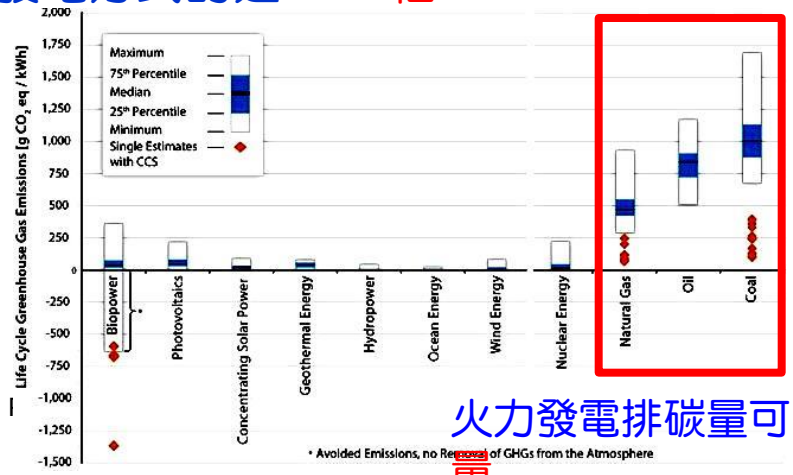
太陽能光電發展

能源枯竭與環境汙染

石化燃料蘊含量在未來50年急速下降，
將伴隨價格飆漲，並在未來200年用盡



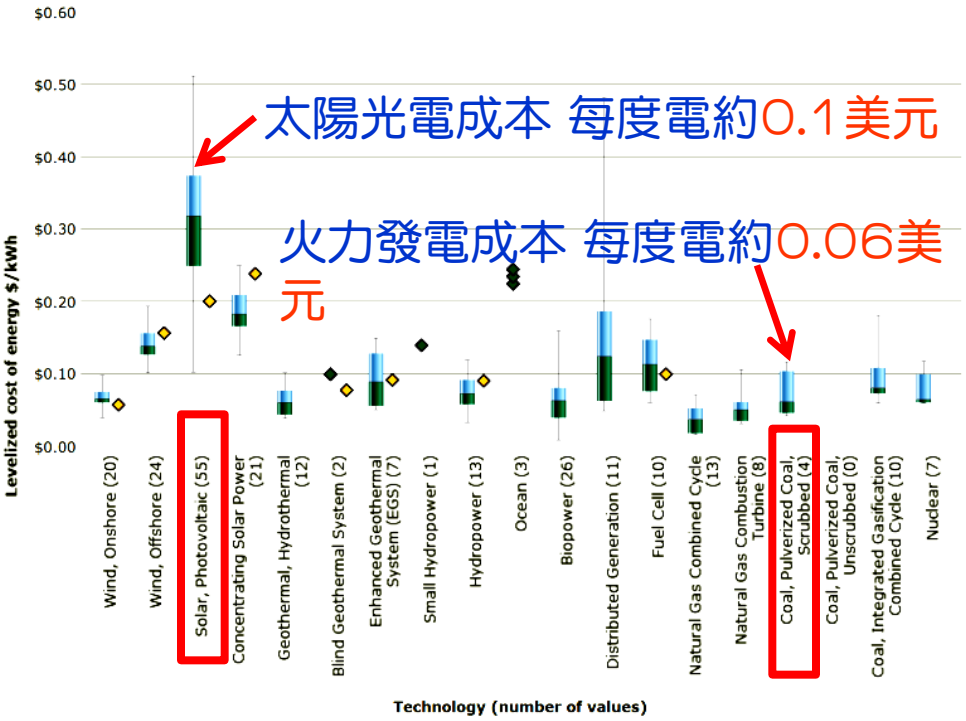
石化能源使用造成的排碳量，是其他
發電方式的近100倍



火力發電排碳量可高達每度1000克當量

高成本的太陽光電產業

太陽能光電廠建置成本仍遠高於火力發電
太陽光電每度電成本約為火力發電的5倍



資料來源
NREL, U.S.A.
Rocky Mountain Institute
OpenEI

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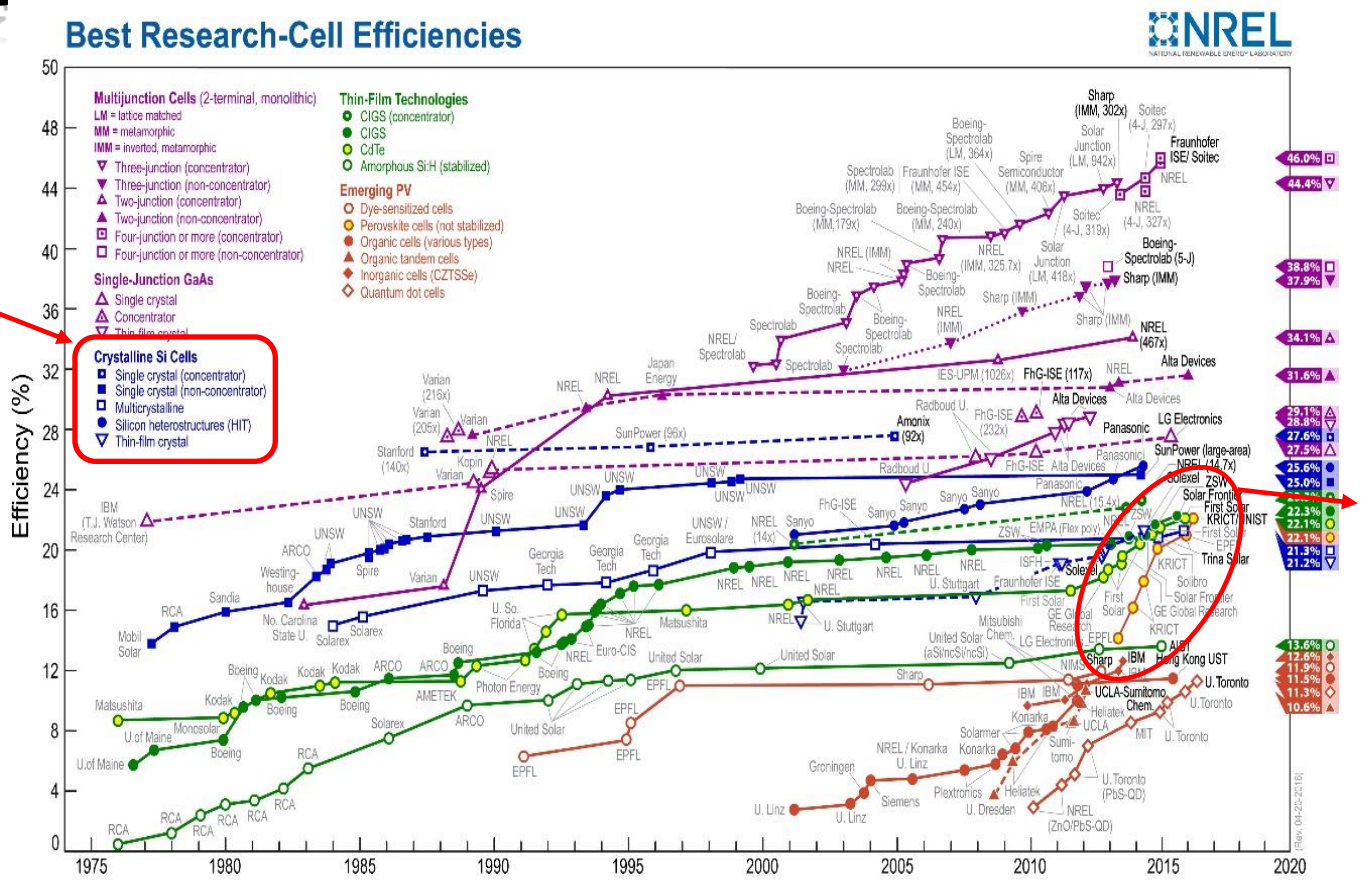
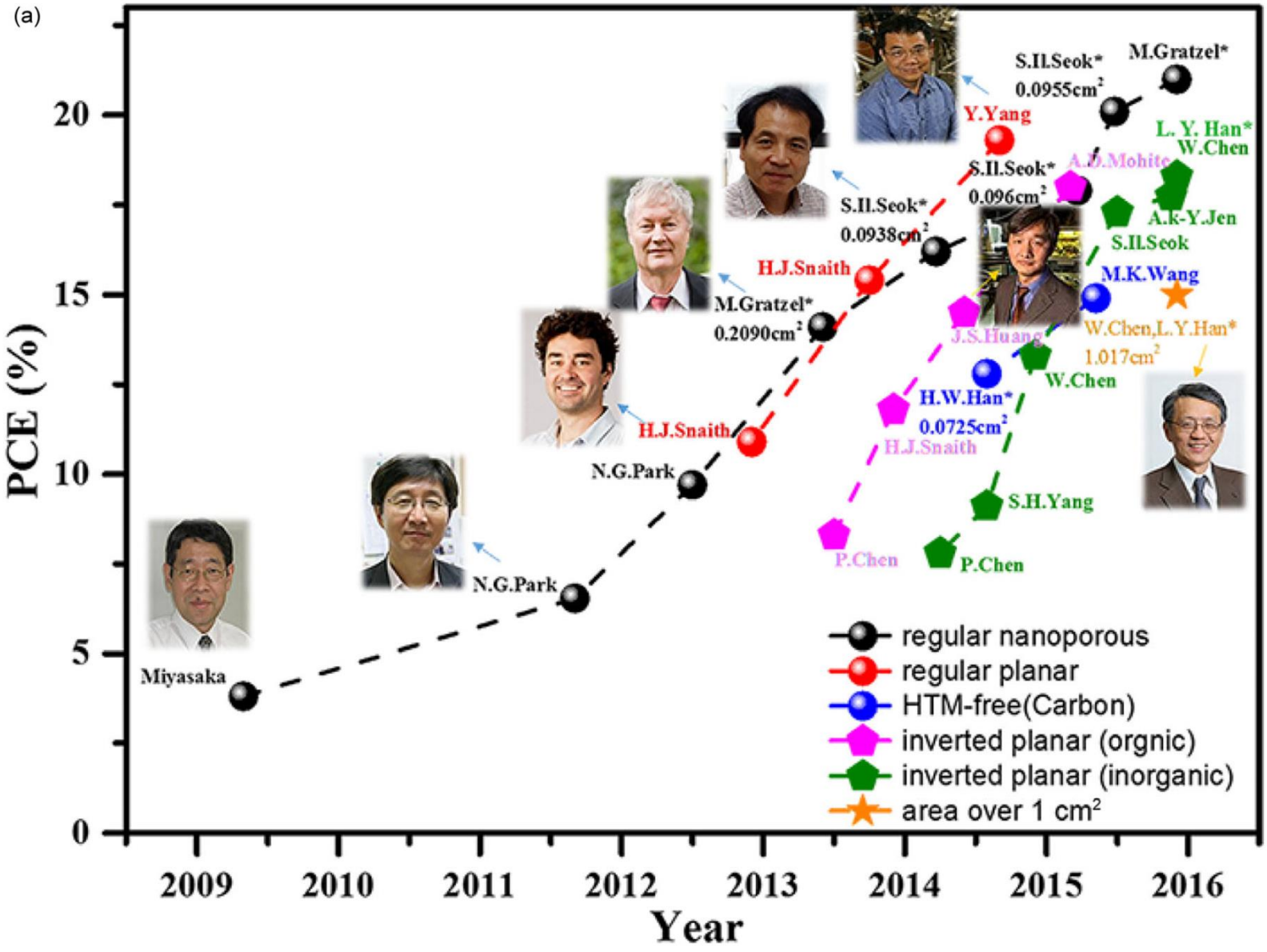
太陽能技術之沿革



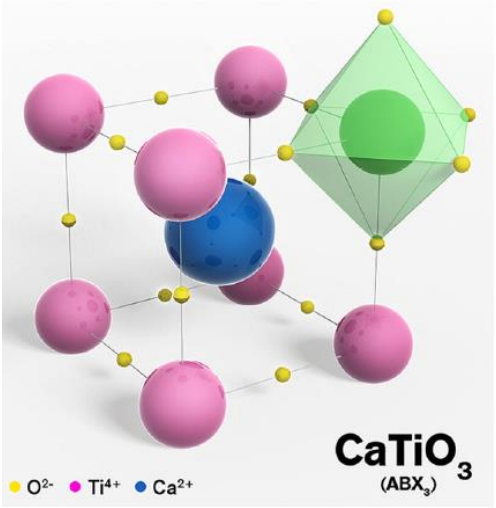
第一代: 矽晶太陽能電池
第二代: 薄膜太陽能電池 (CIGS，a-Si，CdTe)
第三代: 有機太陽能電池 (OPV)，染料敏化太陽能電池 (DSSC)，銅鋅錫硫(CZTS)，量子點(QD)，鈣鈦礦(Perovskite)　溶液製程 Solution process

鈣鈦礦材料的優勢

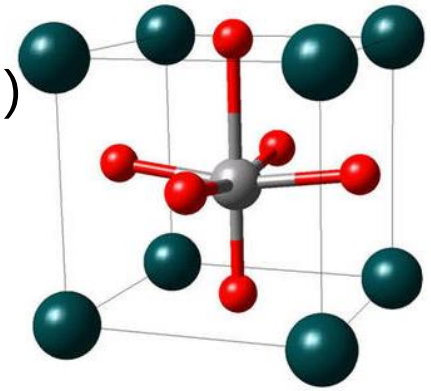

(a)
PCE (%)
Year
0
5
10
15
20
2009
2010
2011
2012
2013
2014
2015
2016
Miyasaka
N.G.Park
N.G.Park
H.J.Snaith
M.Gratzel*
0.2090cm²
H.J.Snaith
S.Il.Seok*
0.0938cm²
Y.Yang
S.Il.Seok*
0.096cm²
S.Il.Seok*
0.0955cm²
M.Gratzel*
L. Y. Han*
W.Chen
A.J.Mohite
A.k-Y.Jen
S.Il.Seok
M.K.Wang
W.Chen,L.Y.Han*
1.017cm²
W.Chen
J.S.Huang
H.W.Han*
0.0725cm²
H.J.Snaith
S.H.Yang
P.Chen
P.Chen
regular nanoporous
regular planar
HTM-free(Carbon)
inverted planar (orgnic)
inverted planar (inorganic)
area over 1 cm²

鈣鈦礦太陽能電池技術

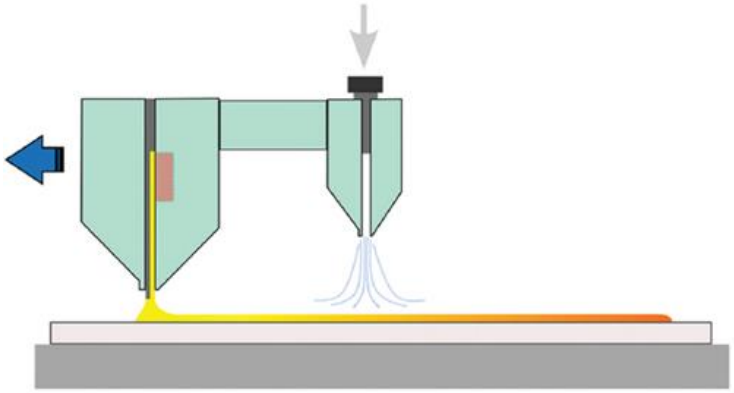
鈣鈦礦材料結構



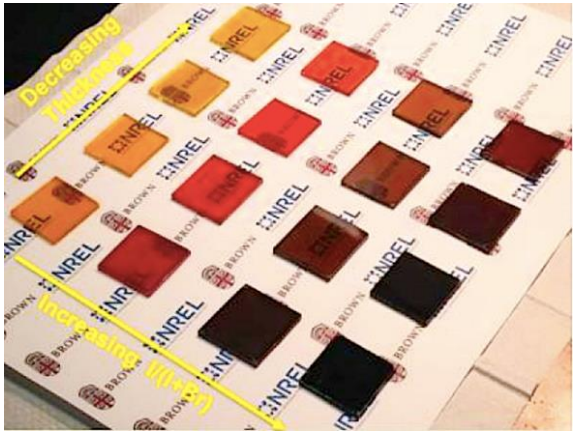
- Organic cations (CH_3NH_3, H2N-CH=NH_2, etc.)
- Halide anions (I, Cl, Br etc.)
- Metal Cation (Pb, Sn, Ge, etc.)



溶液製程鈣鈦礦薄膜太陽能電池

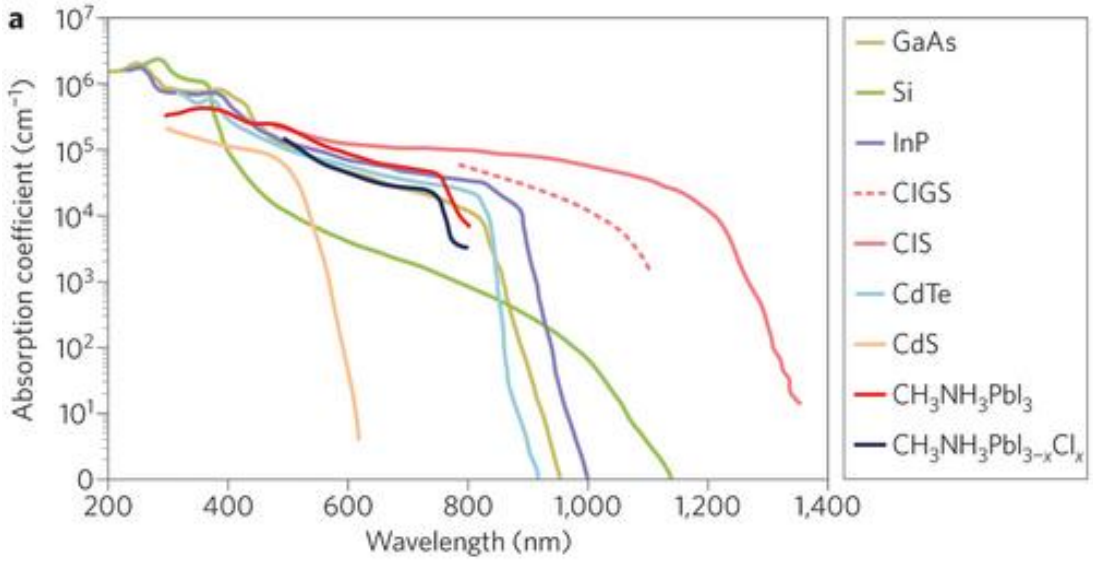


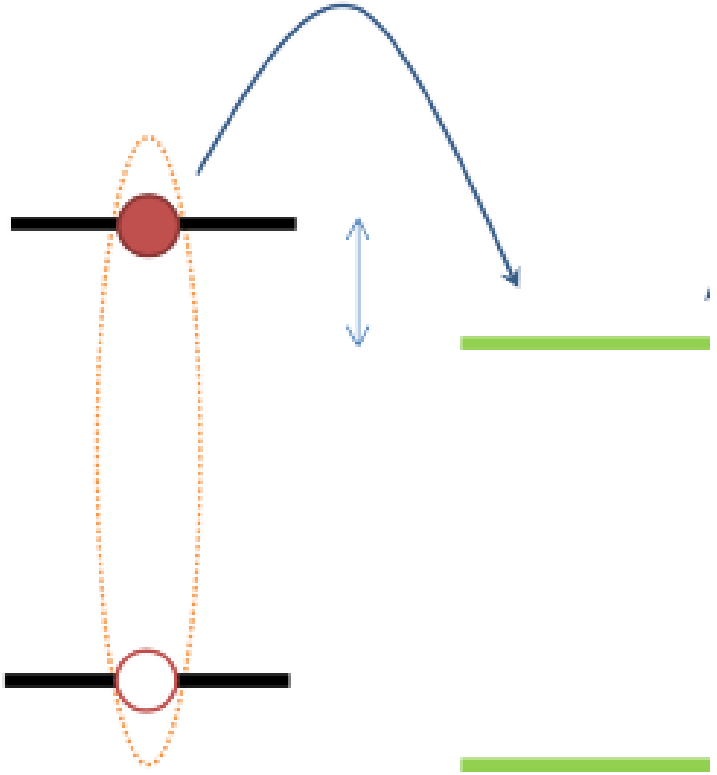
可調之光電性質



鈣鈦礦材料的優勢

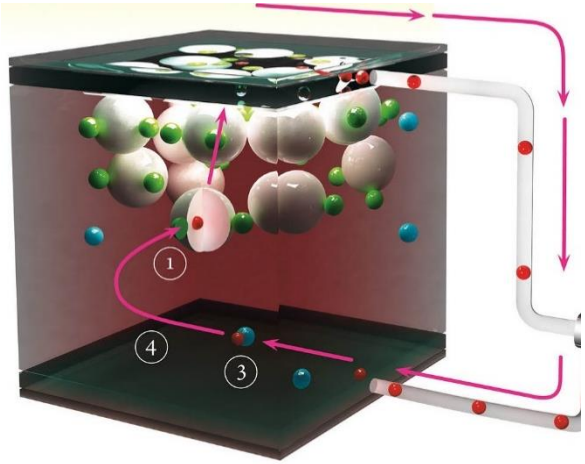
1. Ambipolar materials
2. Long carrier diffusion length
3. High absorption coefficient



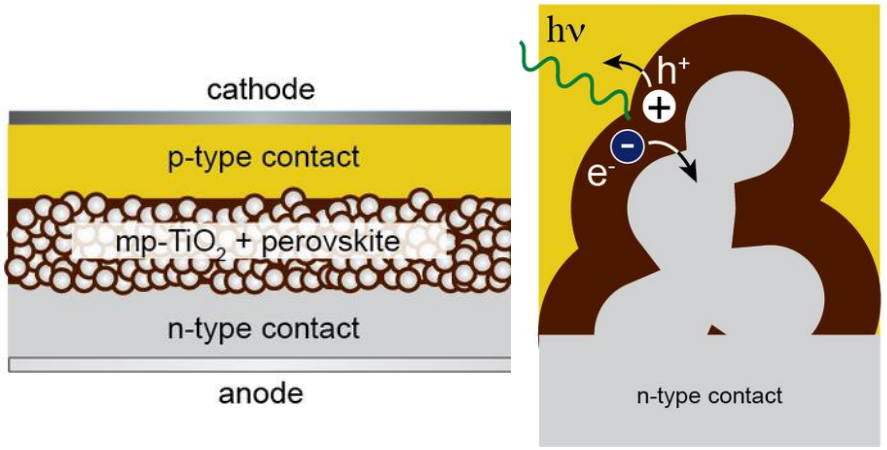


鈣鈦礦太陽能電池技術之發展

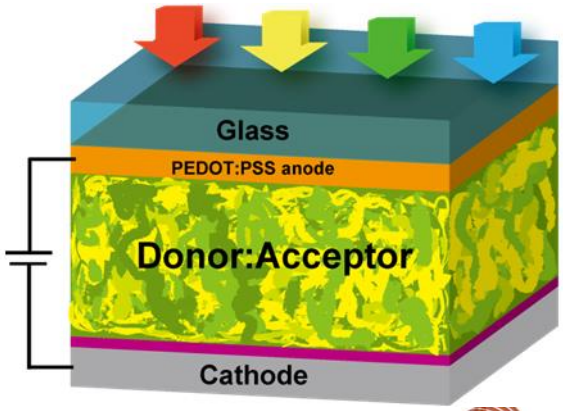
染料敏化太陽能電池 (DSSC)



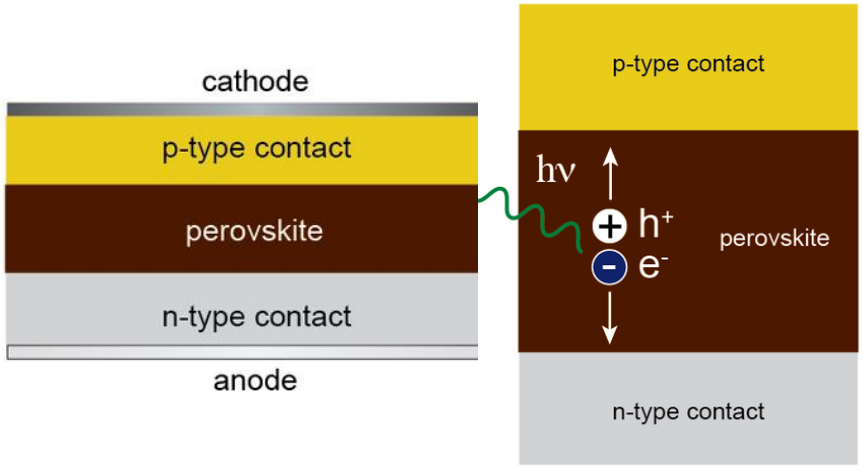
Sensitized perovskite solar cell



有機太陽能電池 (OPV)



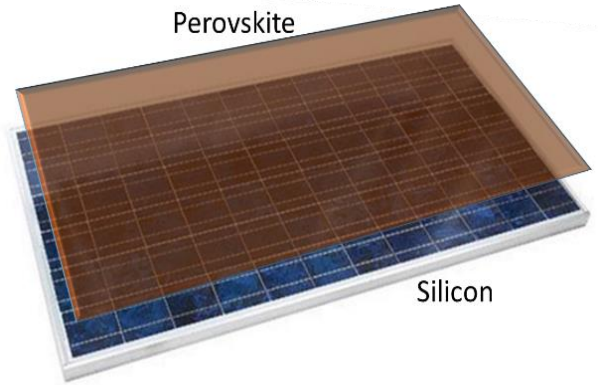
Thin film perovskite solar cell

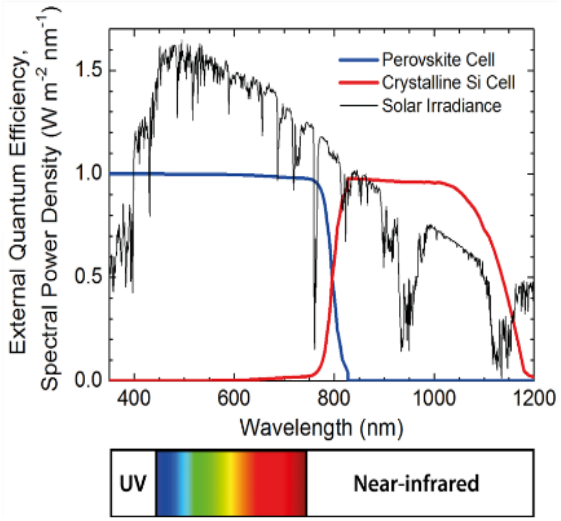


鈣鈦礦光伏技術-市場標的/市場規模

室內應用 - 74 billion USD

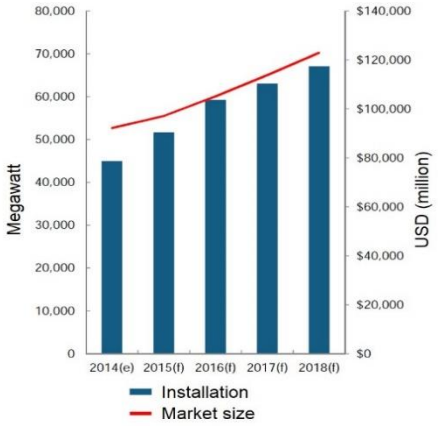
矽晶/鈣鈦礦 疊層型太陽能電池 - 120 billion USD

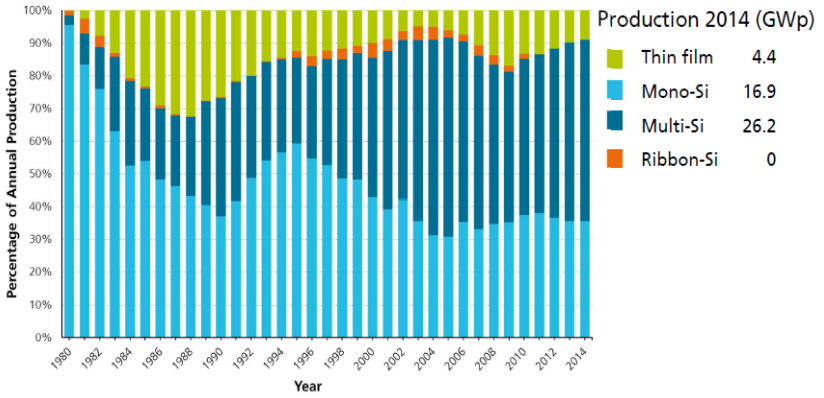




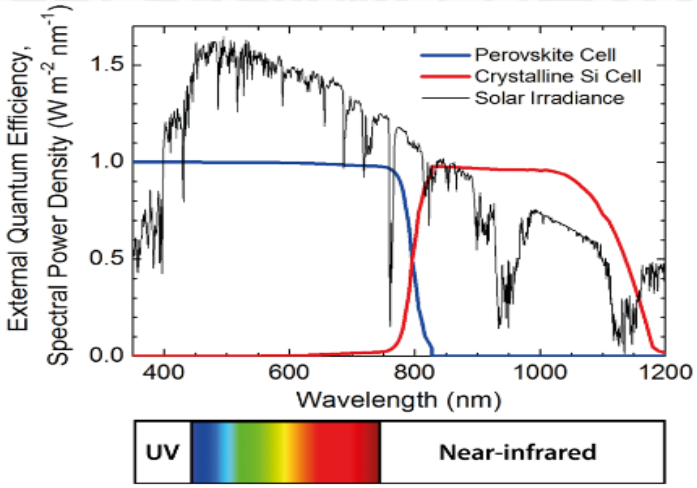
室外獨立發電

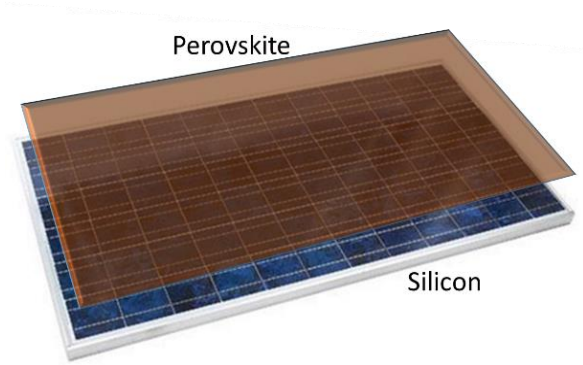
全世界太陽能光電市場規模: 1200 億美金 / 年

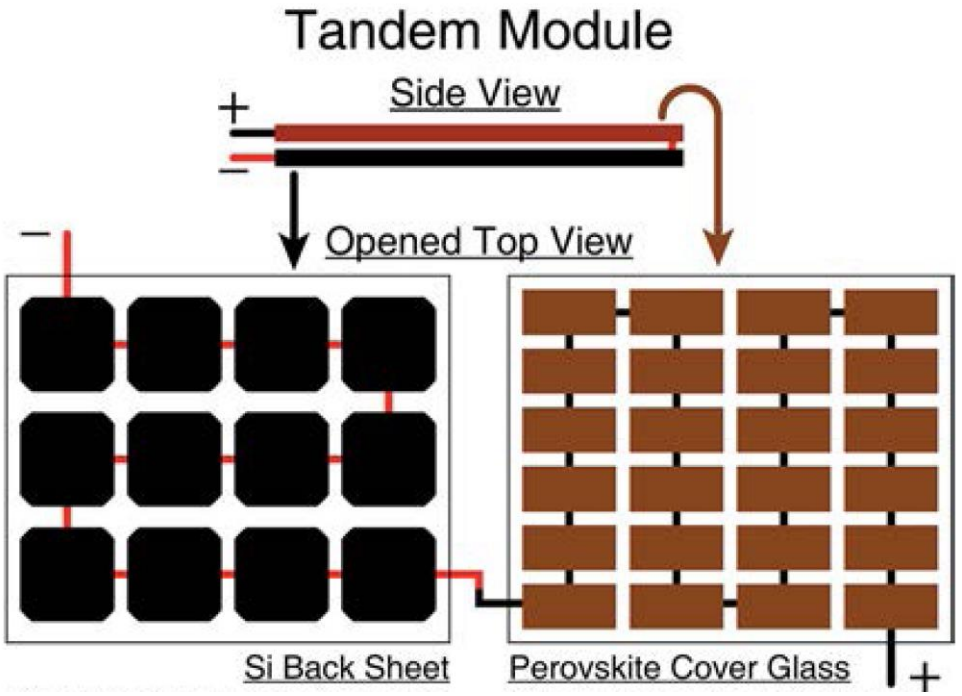




矽晶/鈣鈦礦疊層太陽能電池







代表性太陽能廠商	Module Efficiency (%)	
	Monocrystalline	Polycrystalline
Motech (茂迪)	15.9~17.4	14.7~16.1
Gintech (昱晶)	16.0~17.2	14.8~16.2
Neo Solar Power 新日光	16.9~20.0	15.4~16.7

產學合作技術核心-1

- 鈣鈦礦材料配方

組合

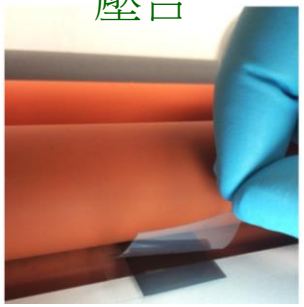
Cs^+，formamidinium (FA^+)

methylammonium (MA^+)，Sn，Pb，Cl^-，Br^-，I^-

- 電極材料/電荷傳導材料/保護層材料

高穩定性金屬氧化物

壓合



濺鍍

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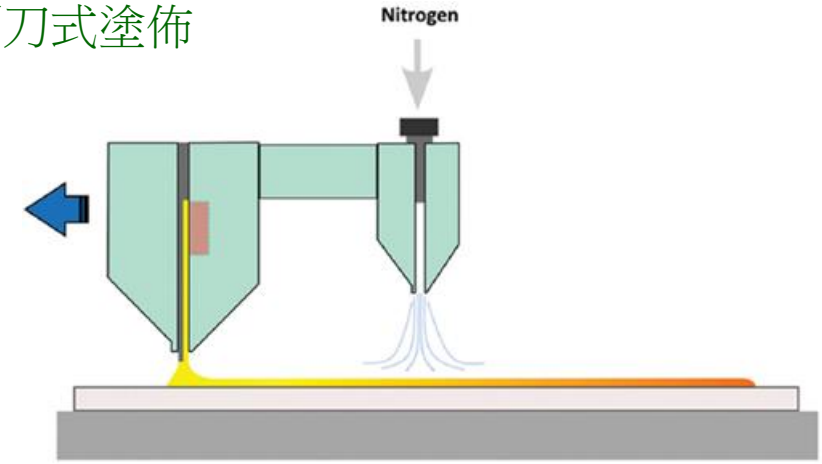
Department of Materials Science and Engineering

產學合作技術核心-2

- 鈣鈦礦量產型製程

刮刀式塗佈



- 鈣鈦礦模組結構

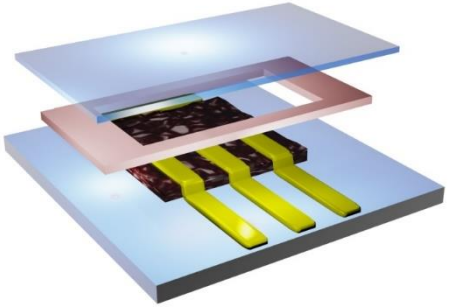
台灣大學機械系 黃秉鈞 特聘教授

National Taiwan University

產學合作技術核心-3

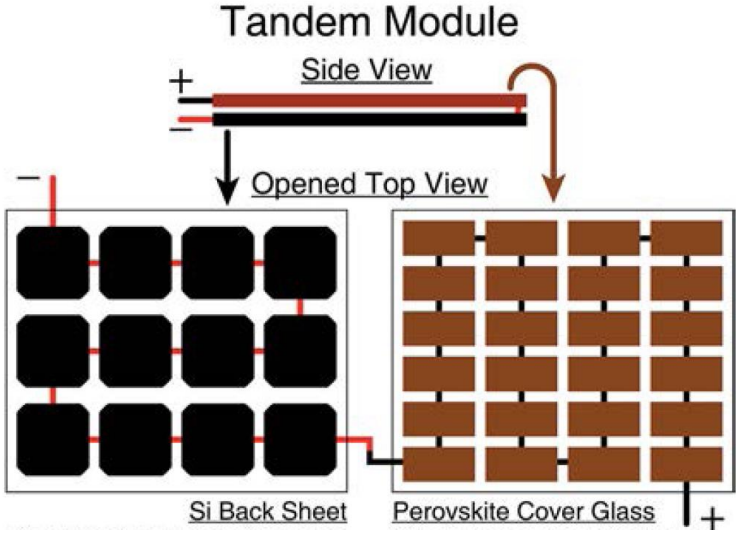
- 模組封裝

高阻濕阻氧



- 疊層模組結構

四接點型疊層太陽能電池



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物理學系
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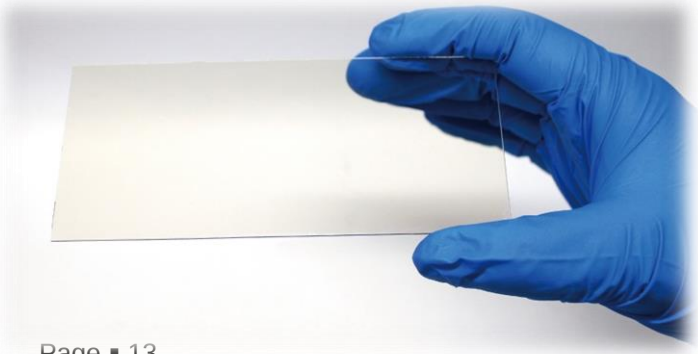
公司現況

- ✓ 成立於2014年
- ✓ 前創科技股份有限公司
  FrontMateirals Co. Ltd. www.frontmaterials.com
- ✓ 實驗室&辦公室:
  台灣大學創新育成中心，桃園龜山
- ✓ 販售項目: 新型光伏電池之特用化學品
- ✓ 客戶分布地區: 台灣，中國，歐洲，美國，韓國。
- ✓ 研發重點: 鈣鈦礦 / 矽晶疊層太陽能電池技術



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合作夥伴

臺灣大學

National Taiwan University

ITRI

Industrial Technology Research Institute

IAPS, NCTU

S.D.U DESIGN

SIMPLE • DIRECT • UNIQUE

TECH

DESIGN

Holst Centre

Open Innovation by IMEC-NL and TNO

GIXIA

GIXIA GROUP 奇想創造

國立台灣大學創新育成中心

TNO innovation for life

永明化工股份有限公司

ECHO CHEMICAL CO., LTD.

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前創科技

IDTechEx-Global Top 10 Player

IDTechEx Services Technologies About Contact

7.4. Bandgap Tuning
7.5. Possible Material Improvement
7.6. Interface Layers
7.7. Polymer HTMs
7.8. Small Molecule HTMs Based on Phenylamine Derivatives
7.9. Small Molecule HTMs without Phenylamine Derivatives

8. PLAYER PROFILES

8.1. Crystalsol (CZTS)
8.2. CSIRO
8.3. Dyesol
8.4. Fraunhofer ISE
8.5. FrontMaterials
8.6. G24 Power
8.7. Oxford Photovoltaics
8.8. Saule Technologies
8.9. Technical Research Centre of Finland (VTT)
8.10. Weihua Solar

Lux Research-Global Top 4 Player

NEWS & EVENTS

Perovskite Solar Cells on the Rise, With Likely Commercialization in 2019

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Perovskite Solar Cells on the Rise, With Likely Commercialization in 2019

The emerging technology reaches 21% efficiency in the lab, leading to deal-making between companies and academic institutions driving research, Lux Research says

BOSTON, MA – April 12, 2016 – Perovskite solar cells are hailed as the next generation of photovoltaic material, and are hoping to drive adoption in new applications. While there are challenges to overcome, perovskites offer several new opportunities for partnerships with universities ahead of a likely commercial deployment between 2019 and 2021, according to Lux Research.

The diverse compounds have seen dramatic achievements in academic labs: From a mere 3.8% efficiency, the cells have rapidly risen to a record 21.0%, compared with 21.7% for competing copper indium gallium diselenide (CIGS) solar cells, which have been in development for decades.

"While the efficiency question has been answered, there remain issues in stability, cost, and the feasibility of real-world efficiencies that must be addressed before commercialization can occur," said Tyler Ogden, Lux Research Associate and lead author of the **report titled**, "The Rise of Perovskites: Identifying the Best Academic Partners to Work With."

"Still, demonstration of their potential for high performance by academic labs has caused research groups to consider spinning off start-ups, meaning companies need to consider opportunities now," he added.

Lux Research analysts evaluated the current state of perovskite solar cells and identified opportunities for companies to partner with academia. Among their findings:

- **Partnerships are emerging from labs.** Dyesol has partnered with Michael Grätzel's lab at EPFL, which achieved the world record efficiency of 21.0% in December 2015. Oxford Photovoltaic is working with Henry Snaith of Oxford University, while Poland's Saule Technologies has roots from the University of Valencia and Taiwan's Front Materials from the National Taiwan University.

TOP 4 perovskite partnership in the world

- ✓ **Dyesol – EPFL**
- ✓ **Oxford PV – Oxford University**
- ✓ **Saule – University of Valencia**
- ✓ **FrontMaterials – National Taiwan University**

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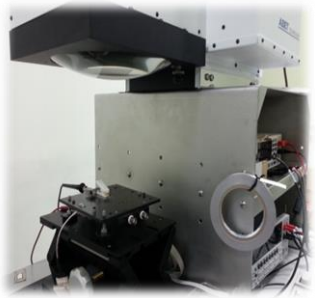
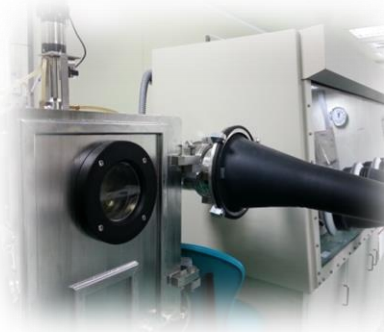
鈣鈦礦 R&D Total solution

2016 / 12 / 01 Online





Chemicals + Instrument + supply

A total solution for perovskite research

FRONTMATERIALS

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- Researcher, MITSUBISHI Japan

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Shi-Han Huang, Kai-Chi Shao

- Ph.D. and master of Materials Science, National Taiwan University

感謝聆聽與指教

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