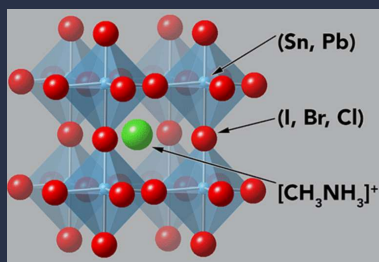


Vers l'industrialisation des cellules solaires tandem en pérovskite à haut rendement

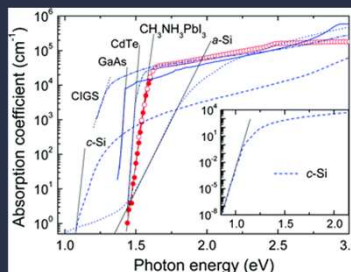
Sylvain Nicolay

1

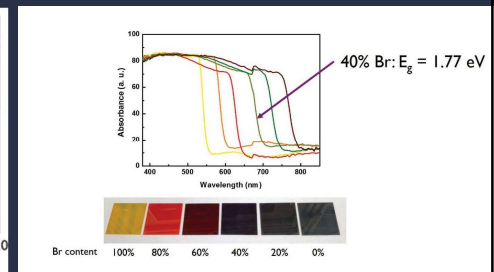
What is perovskite?



<https://arstechnica.com/science/2016/01/layered-perovskite-on-silicon-could-boost-pv-efficiencies-to-30-percent/>



The Duong PhD Thesis, ANU 2017

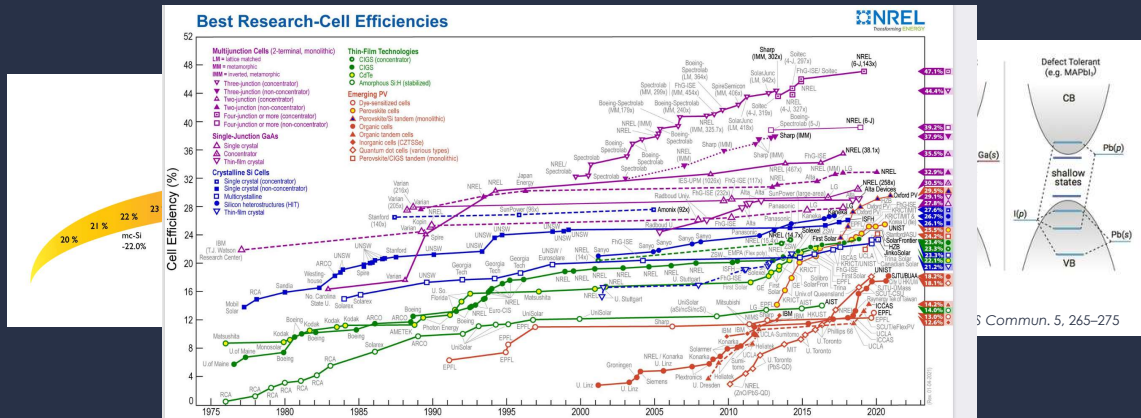


<https://www.solarpowerworldonline.com/2015/04/the-perfect-marriage-silicon-and-perovskite-solar-cells/>

- An hybrid organic-inorganic compound
- Good light absorption properties
- Widely tunable light absorption energy onset

2

Why perovskite?

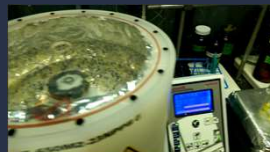
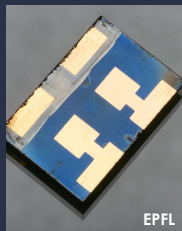


- Efficiency potential for single cell > efficiency of c-Si
- Ideal candidate for tandem device using c-Si bottom cell
- Simple to process and highly defect tolerant

3

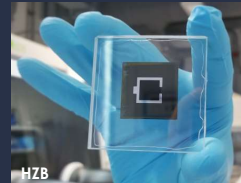
Perovskite in the lab

Single junction

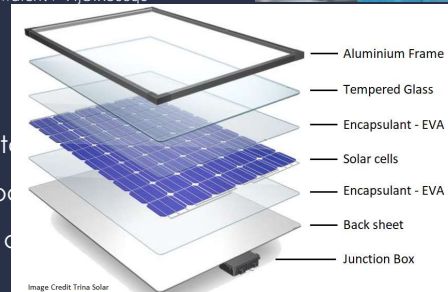


<https://www.youtube.com/watch?v=9TjCTXcU8qU>

Tandem junction



- Few mW
- Non-sig
- Non-sig
- But effi



4

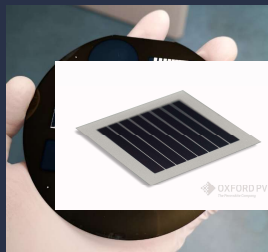
Perovskite in the «fab»

Single junction module @ 16%



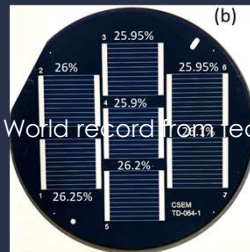
Tandem junctions (CSEM)

On smooth c-Si



27.5%

On standard c-Si



26%

On large area



23%

World record from technology leader: 28%

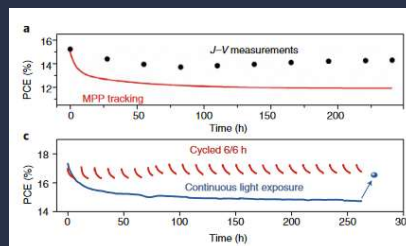
- Efficiency drop when upscaling and using production oriented materials and processes
- Still very promising efficiency achieved on upscalable devices

csem

5

Perovskite in questions

- Stability: Not only lab tests but also in the field.



M. Khenkin et al. NATURE ENERGY

| VOL 5 | 2020 | 35–49 |

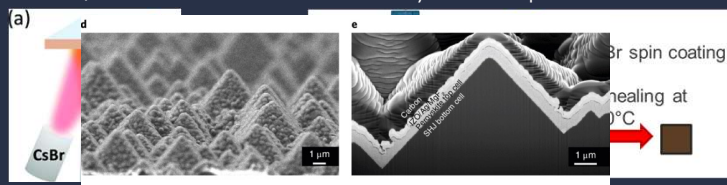
6

- Production (technique + wafer)

Full evaporation

Hybrid: Evaporation+wet

Slot die

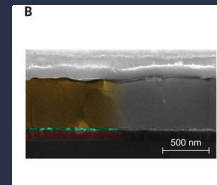


R. Ji et al.

J. Mater. Chem. C, 2020, 8, 7725–7733

A. Subbiah et al.

ACS Energy Lett. 2020, 5, 3034

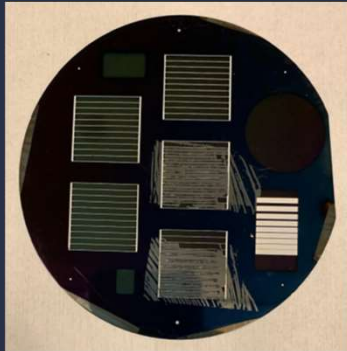


6

Perovskite in questions

- Interconnection and costs:

Fragile interfaces



BOM cost not adapted

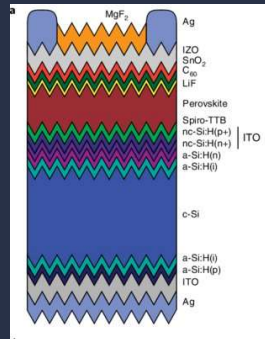


Table S8. Materials costs for perovskite/silicon tandem module fabrication

Component	Raw material	Price (\$/kg)	Weight (g/m ²)	Material cost (\$/m ²)
Front glass	3 mm Glass (with Ag)	0.85 (0.85-1.10)	7500	7.000
ITO	ITO	700 (550-900)	2.09	1.520
SnO ₂	SnO ₂ (stove)	190	0.035	0.004
LiF	LiF (stove)	8000	0.003	0.004
Perovskite	Perovskite	700 (400-1400)	2.30	0.980
Perovskite	Perovskite	450 (250-750)	0.33	0.086
Cu	Cu	160000	0.026	5.467
NO	NO	200 (100-400)	0.007	0.143
Cu	Cu	9.0	1.11	0.010
Solder wire	Sn	10	1.365	0.011
Edge seal	Al	2.2 (0.3-2.3)	1555	3.888
Lamination	EVA	11.0 (9.0-14.2)	138	1.535
Edge sealant	Butyl rubber	2.0 (1.0-5.0)	10.5	0.037
Back glass	2 mm Glass	0.8 (0.4-0.8)	5000	3.000
Junction box	N/A	N/A	N/A	7.500

Zongqi Li et al. Joule (2018) <https://doi.org/10.1016/j.joule.2018.05.001>

csem

7

Perovskite (no-)future ?

- Perovskite has demonstrated the potential to be a breakthrough PV technology.
- Relevant research should focus on making it an industrial product:
 - Large scale, reliable, low-cost production process compatible with GWp capacity
 - Interconnection and encapsulation for low CTM losses
 - Field stability
- Industry and research goes hand-in-hand: support for both is required

Support should come now. Not when installing EU/CH made high efficiency PV will be needed!

csem

8



9