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FNSNF

Upscaling perovskite solar cells

Jun-Ho Yum, Soo-Jin Moon, Laurent Sansonnens, Linus Löfgren, Sylvain Nicolay, Julien Bailat, Christophe Ballif

PV-Center, CSEM, Jaquet Droz 1, 2002 Neuchâtel

csem

Motivation

Upscaling of perovskie solar cell for ultra-high performance tandem photovoltaic energy system

What is the top cell material on Si-bottom cell?

The organometallic halide perovskite

Record efficiency: **17.9%** (KRICT, certified by NREL)

http://www.nrel.gov/ncpv/images/efficiency_chart.jpg

What are the advantages of the organometallic halide perovskite?

1. Tunable dimensionality
2. Tunable optical and electronic property
3. Low-cost process-based solution process
4. High molar extinction efficient
5. Steep absorption onset and no optically detected deep states

However, all reported high performance have been achieved on laboratory scale area below 0.5 cm^2.

CSEM task is to upscale perovskite solar cell:

CSEM will focus on optimizing perovskite layer *via* production-oriented processes such as wet coating, spin-coating or new innovative coating, with the final aim of transferring the high efficiency achieved in the labs to pre-production scale mini-modules

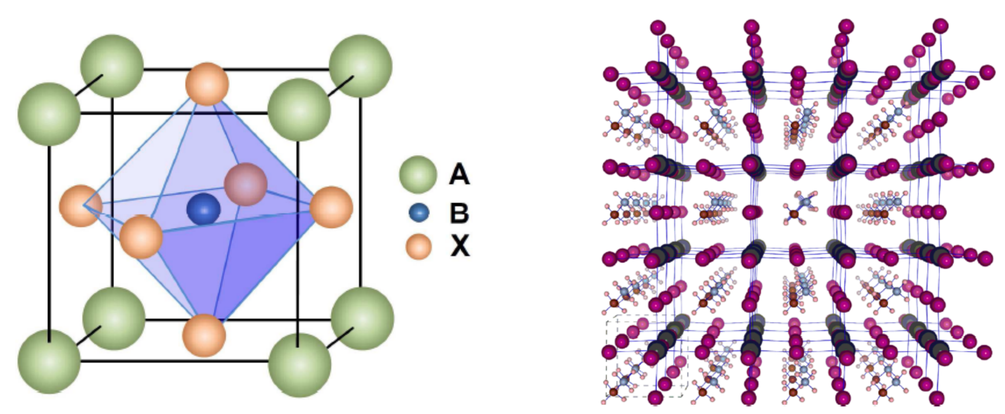


Figure 1. Perovskite structure (Hui Seon Kim et al., J. Phys. Chem. C 2014, 118, 5615)

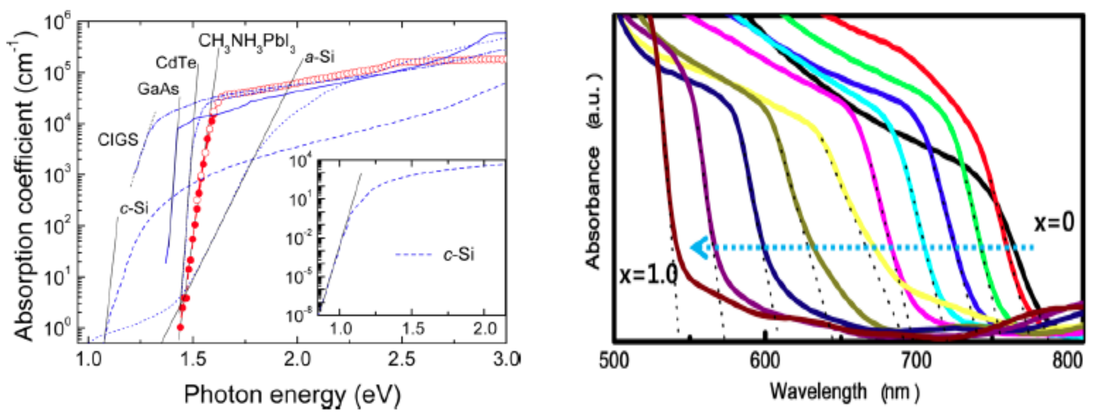
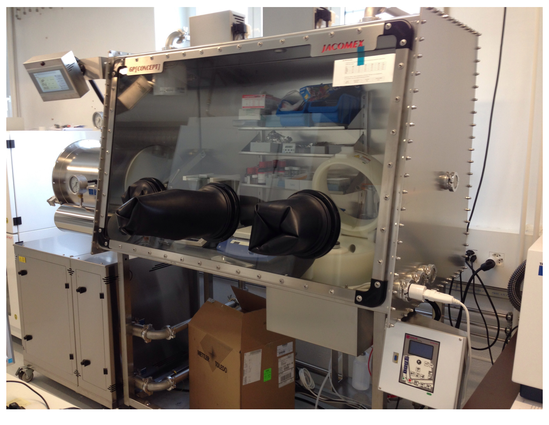


Figure 2. (Left) Absorption coefficient of $CH_3NH_3PbI_3$ perovskite compared to other photovoltaic materials (Stefaan De Wolf et al., J. Phys. Chem. C 2014, 5, 1035) and (Right) absorption spectra of $CH_3NH_3Pb(I_{1-x}Br_x)_3$.

Device fabrication



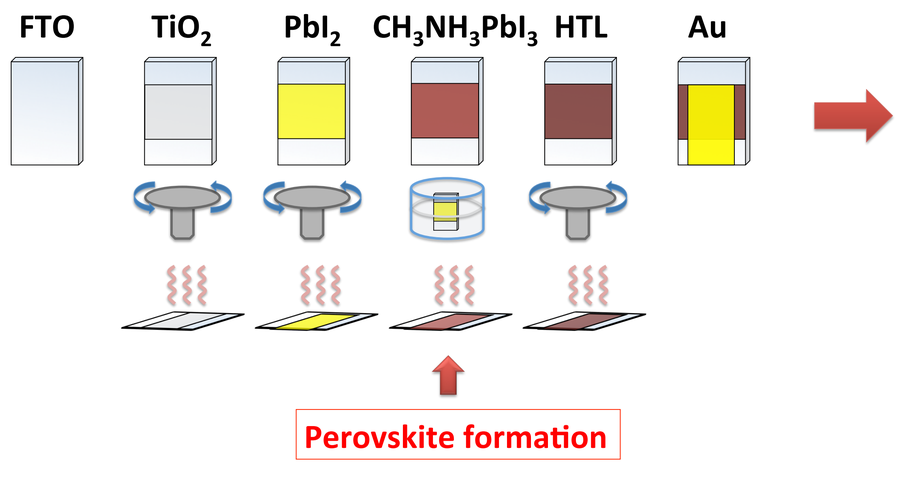


Figure 3. Perovskite solar cell fabrication process.

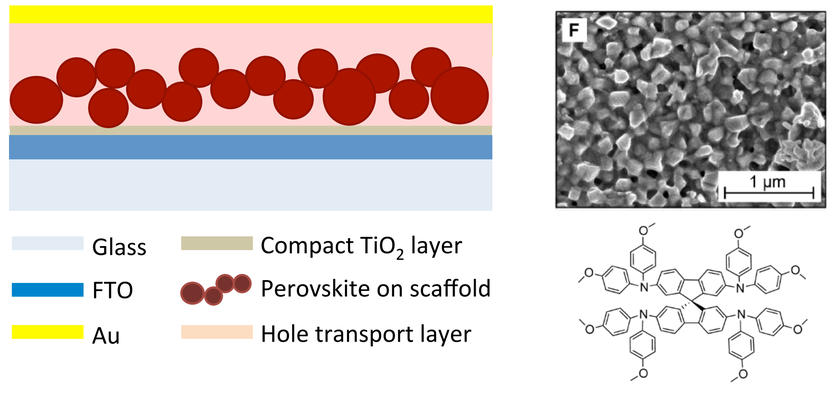


Figure 4. Device structure, SEM of perovskite on TiO_2 scaffold (Julian Burschak et al, Nature 499, 316) and molecular structure of HTL, spiro-OMETAD.

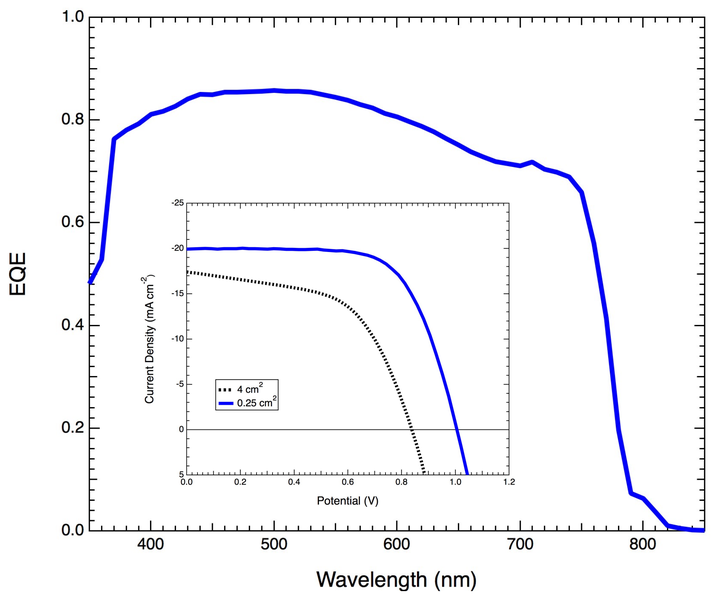
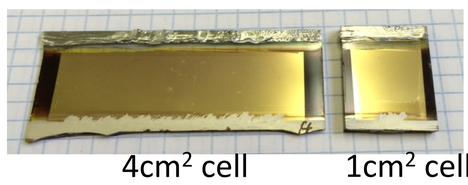


Figure 5. EQE of the best cell and (insert) IV result of perovskite solar cells with different active area.

Result



4cm^2 cell 1cm^2 cell

Active area	PCE [%]	Voc [mV]	Jsc [mA/cm^2]	FF [%]	Rsc [Ohms.cm^2]	Roc [Ohms.cm^2]
0.25 cm^2[a]	**13.7**	1010	20.0	67.7	2.63E+04	9.42
1 cm^2[a]	**12.8**	1030	20.4	60.8	2.10E+03	9.88
4 cm^2[b]	**8.15**	839	17.4	55.9	2.69E+02	12.5

[a] FTO from Pikinton, [b] FTO from CTEC

Further work

New pin-hole free compact layer development in order to mitigate recombination loss

Process engineering for large substrate to achieve uniform layers

Minimodule development with the use of laser scribing