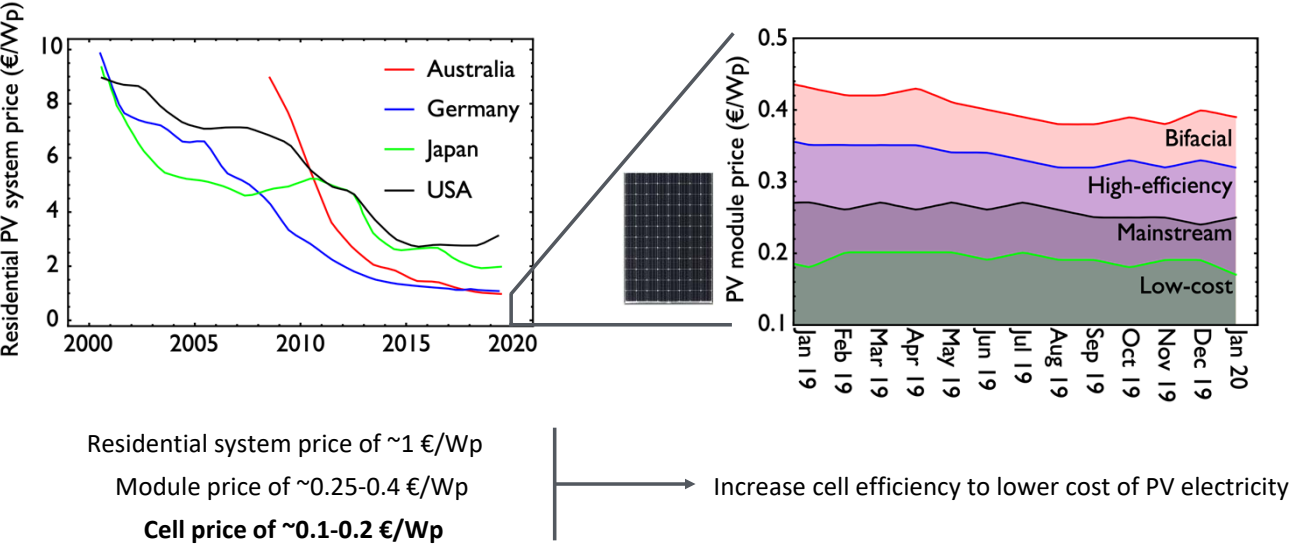


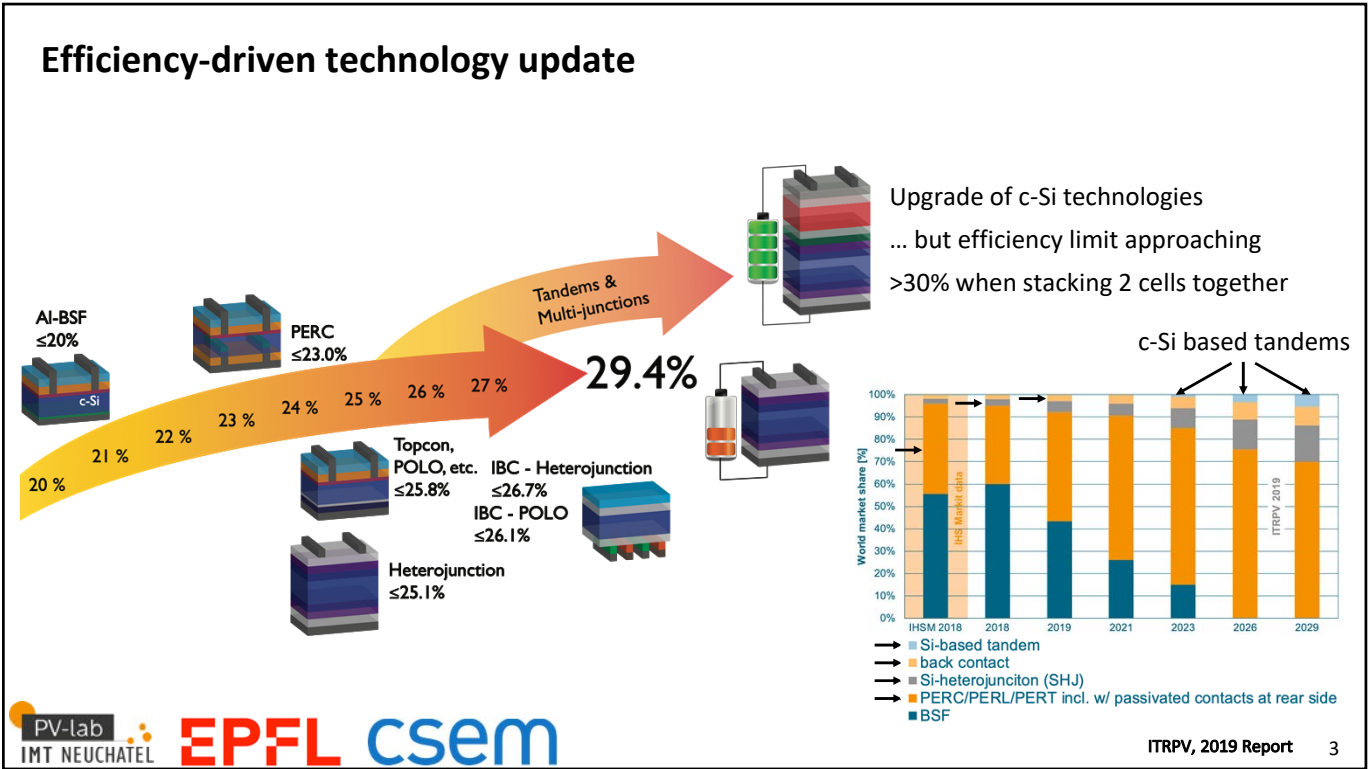
# Cellules solaires tandem pérovskite-silicium: statut de la technologie

1

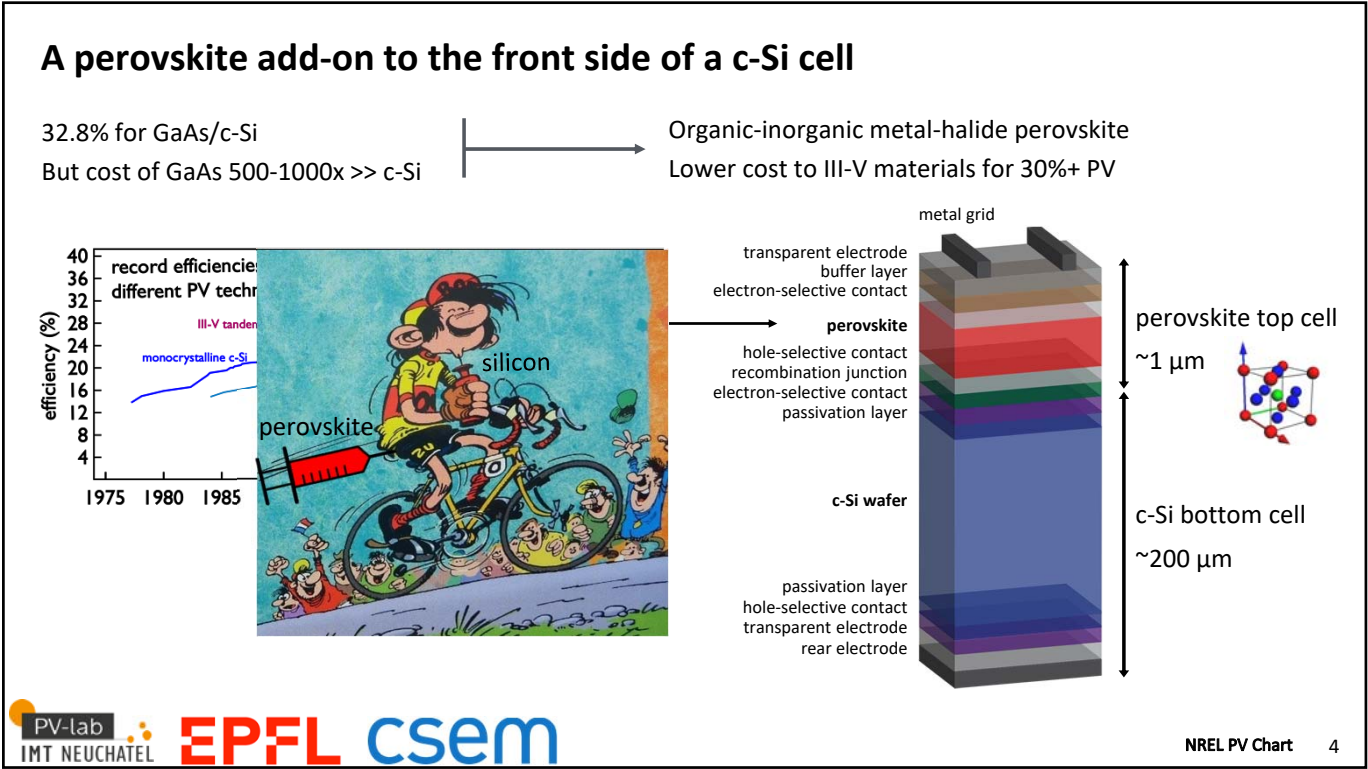
## Economics of silicon photovoltaics



2



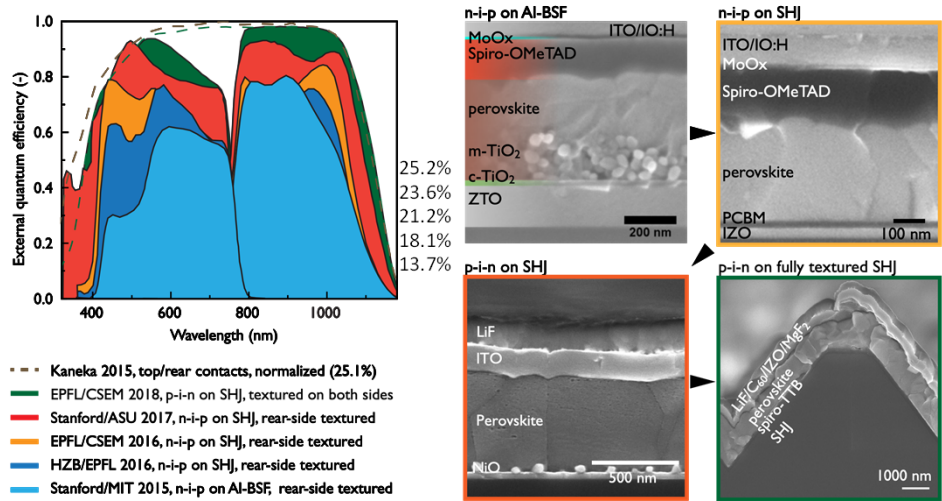
3



4

### Perovskite/c-Si tandems, some processing milestones

First set of developments linked to specific process developments & optical design

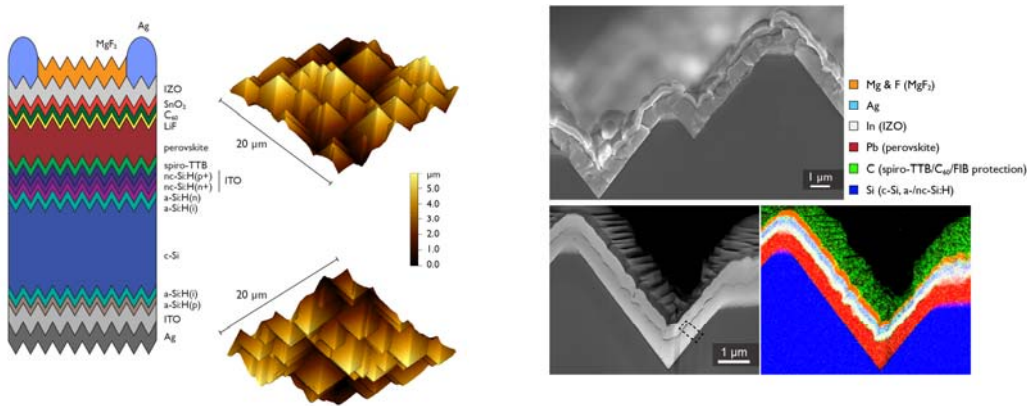


### Perovskite/c-Si tandems with textured wafers

c-Si pyramidal texture for optimal light management

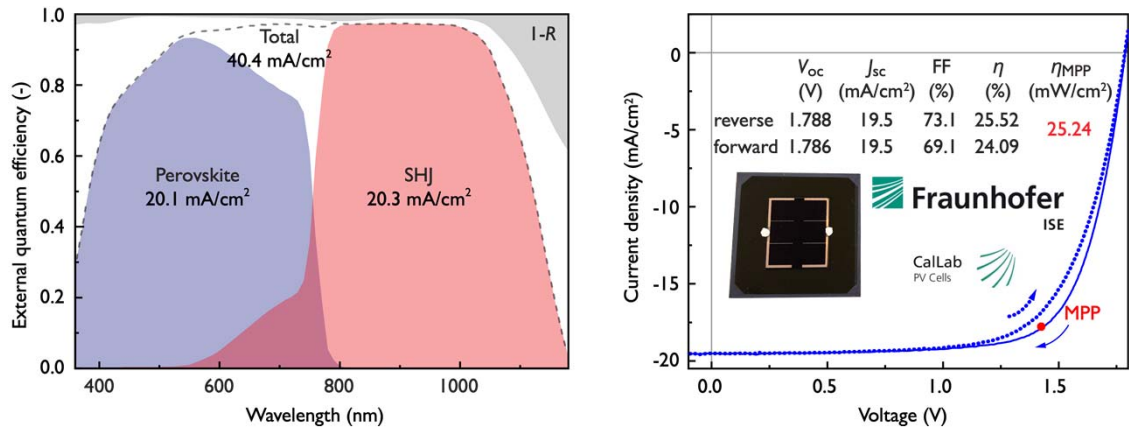
Incompatible with conventional spin-coated perovskite deposition routes

Conformal coating of CsFAPb(I,Br)<sub>3</sub> perovskite thanks to hybrid evaporation/spin coating method



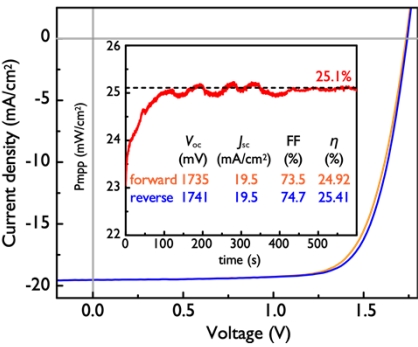
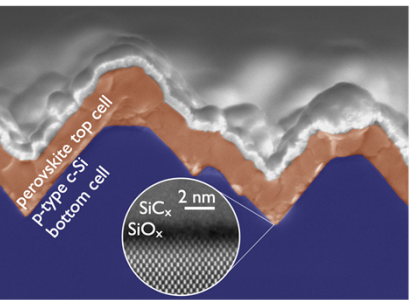
25.2% certified monolithic tandem on textured c-Si

1.42 cm<sup>2</sup> nc-Si:H-based-tandems with a 1.6 eV top cell  
25.2% at MPP (certified)  
Gain of >3%<sub>abs</sub> compared to bottom c-Si cell alone



7

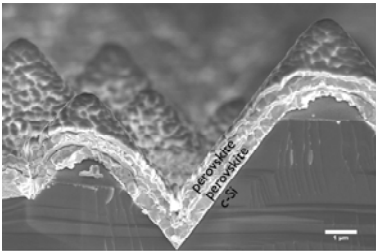
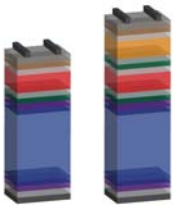
A versatile technology



On p-type wafer, the industry standard c-Si cell based on high temperature passivating contacts

G. Nogay et al., ACS Energy Lett. 4 (2019) 844–845.

From tandems to triple-junctions



First demonstration of a triple-junction

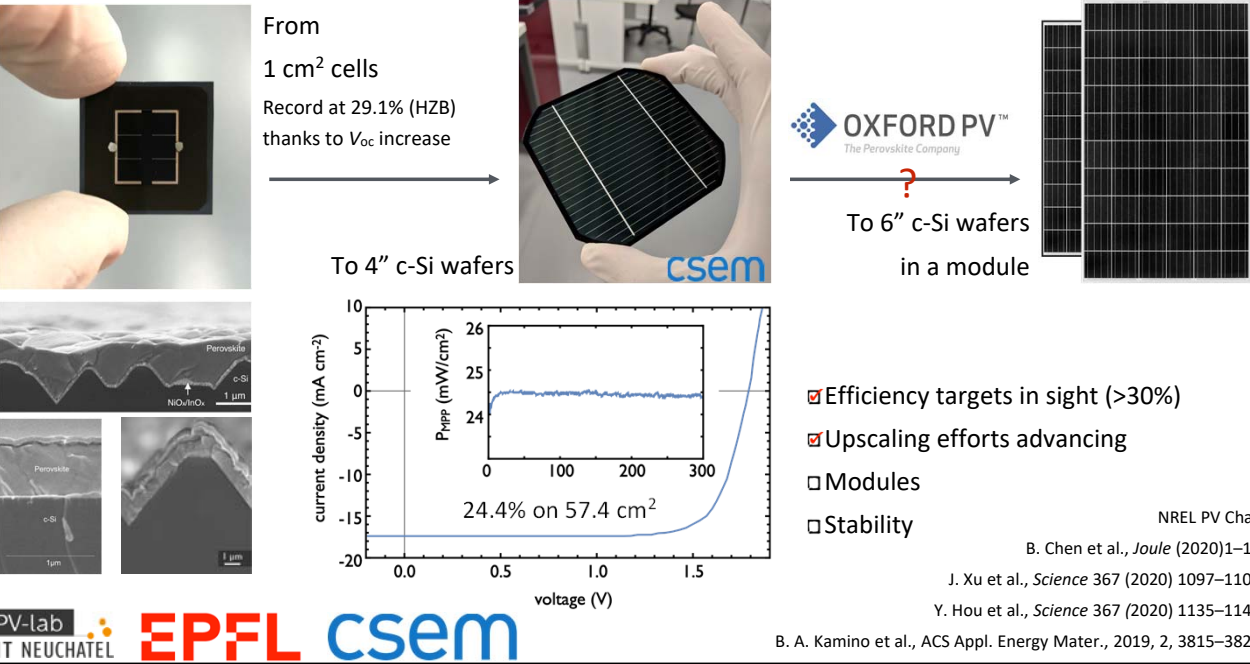
$V_{oc}$  of 2.7 V, efficiency of 13%

J. Werner et al., ACS Energy Lett. 3 (2018) 2052–2058.

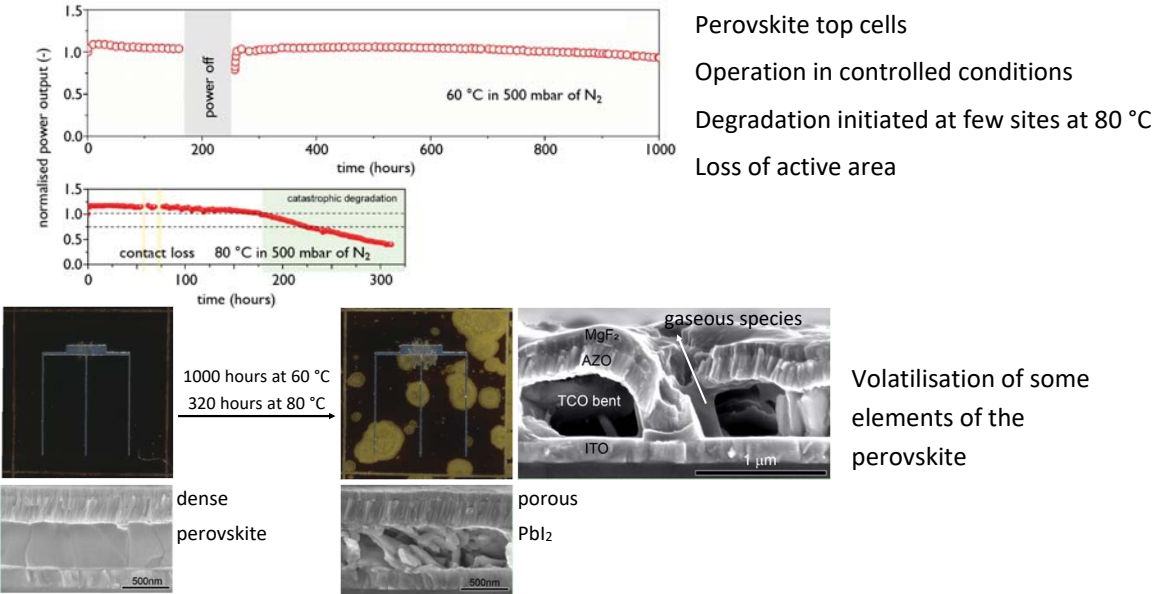
8

8

Upscaling of perovskite/c-Si tandems



Operational stability of perovskite single-junction cells



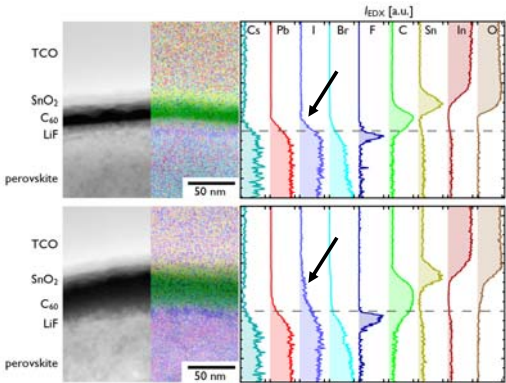
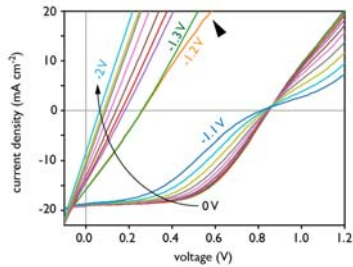


### Degradation induced by partial shading

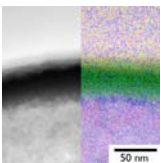
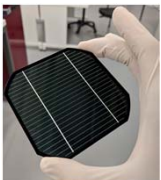
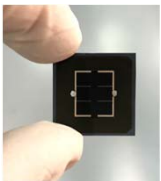


Partial shading brings shaded cells into reverse bias (forward bias normally)  
Severe degradation in many thin film solar cell technologies  
Also triggers various degradation mechanisms in perovskite cells

- Shunt formation at the metal electrode
- S-shape due to halide migration



### Conclusions & outlook



#### Some academic highlights

Efficiency promises being fulfilled (on small areas)  
Progress with respect to upscaling  
Still question marks over stability aspects

#### Global picture

ITRPV predicts tandems on the market within the next 5 years  
Silicon cell manufacturers investing in R&D efforts  
Oxford PV - Meyer Burger partnership

- Objectives of 30% in 2020 with M2 wafers
- Module integration
- 250 MW line being installed in Germany, plans for GW

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