POWER: High-performance tandem solar cells with improved stability and cost-competitive manufacturing

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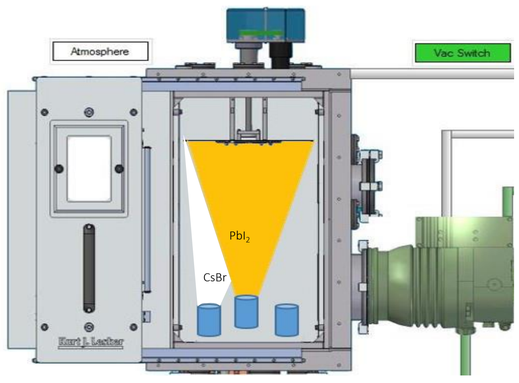
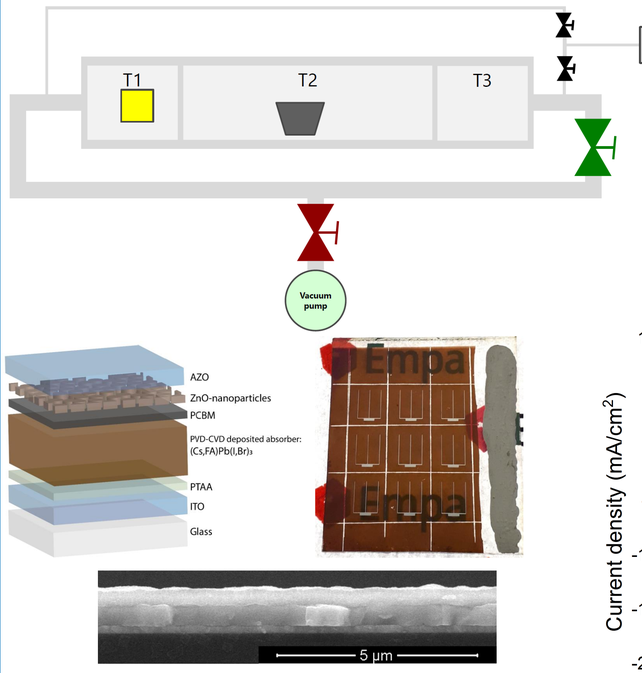
The POWER Project aims to develop a new generation of solar cells by combining emerging perovskite cells with market-proven CIGS and crystalline silicon cells. By combining scientific excellence with innovation and production oriented development, the project will pave the way towards the realization of low cost solar cells with >30% performance, surpassing 25 years lifetime.

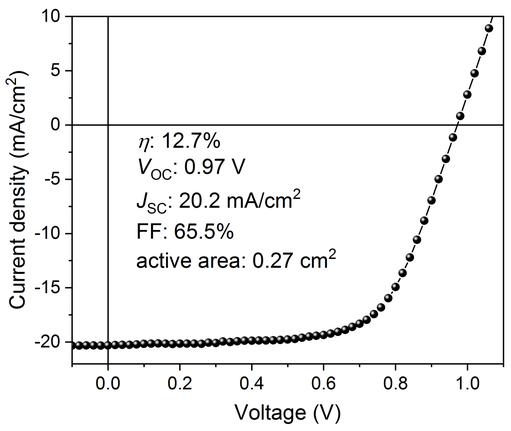
A scalable hybrid deposition technique

- A scalable hybrid evaporation-CVD technique has been developed
- First a CsPb(I,Br) template is evaporated under high vacuum
- An organo-halide component (e.g. FAI) has then to be incorporated to form the photoactive perovskite
- This can be done by either spin-coating from a solution or a CVD-like technique



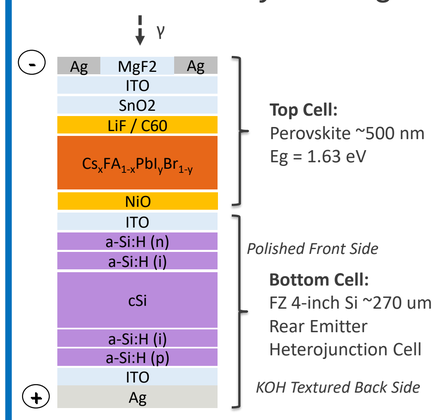


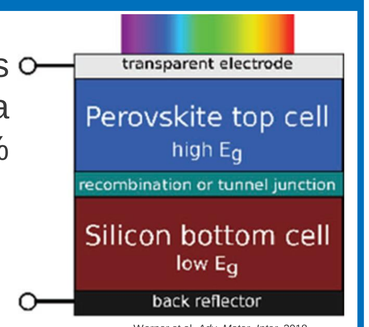
- A custom CVD reactor was developed in the form of a multizone tube furnace with reversible carrier gas flow for a fine control of the heating and deposition steps



PK/Si tandems: towards industrialization

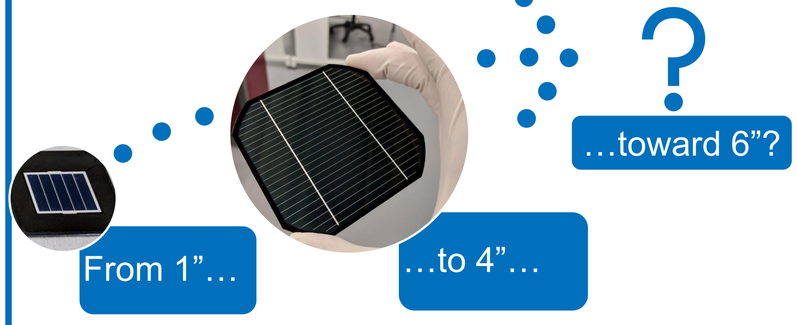
- Perovskite on low-bandgap absorbers (such as CIGS and Si) tandem devices are seen as a promising way of bringing PV across the 30% PCE limit by limiting thermalization losses



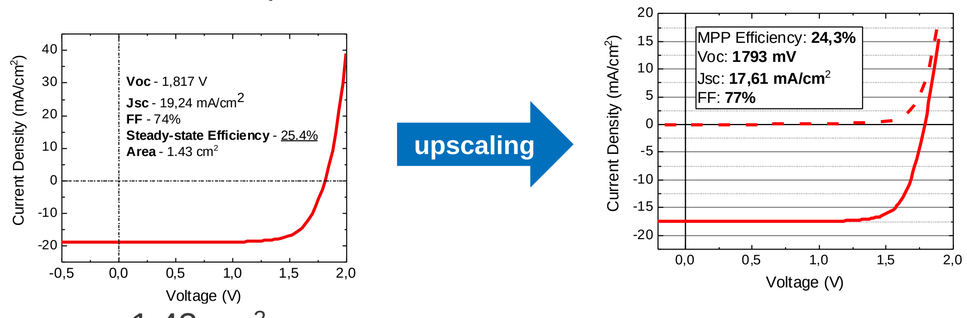


Werner et al. *Adv. Mater. Inter.* 2018

- Si Heterojunction is used as bottom cell
- Excellent passivation of bottom cell provides high V_{OC} and good NIR response
- Top cell absorber is deposited by solution processing (spin-coating), all contact layers by PVD



- POWER provides a platform for the development of industry relevant processes for the contacting of tandem devices
- Screen printing of industrial low-temperature silver paste was demonstrated to contact a 57.4 cm² cell



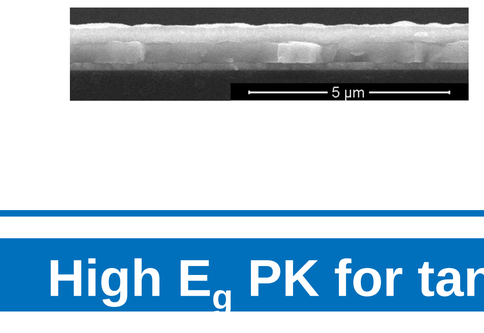
1.43 cm² 57.4 cm²

B.A. Kamino *et al.*, ACS Appl. Energy Mater. 2019

High E_g PK for tandems: phase stability?

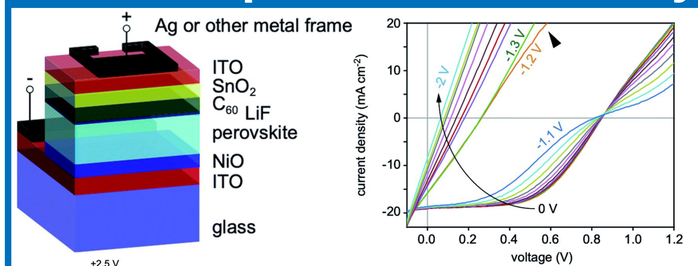
- Most favorable top cell bandgap in tandem with Si bottom cell is about 1.7 eV
- Bandgap is tuned by varying Br/I ratio in a $Cs_yFA_{1-y}Pb(I_xBr_{1-x})_3$ PK
- However, perovskites with E_g > 1.65 eV are prone to halide segregation under illumination
- This was evidenced through T-dependent PL for various E_g

- SEM cathodoluminescence evidenced the formation of small regions of low bandgap with high emissivity within a matrix of high bandgap material



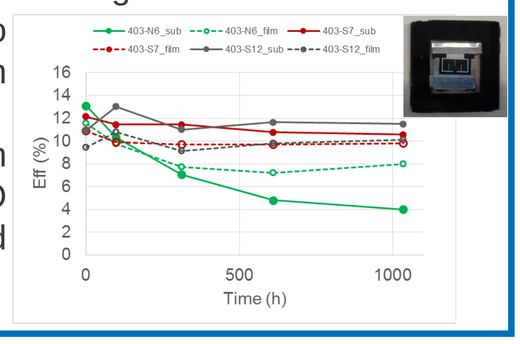
- Leads to high external PLQY while absorption measured through PDS remains largely unchanged
- Additives are under investigation that passivate grain boundaries and hinder halide migration

Operational stability of PK cells



R.A.Z. Razera *et al.*, J. Mater. Chem. A, 2020

- Degradation under reverse bias: 2 different regimes
- Down to -1.1 V: s-shape, reversible after light soaking at MPP
- Below -1.1 V: breakdown, irreversible shunting of the device due to metal migration from the electrodes
- S-shape formation shown to be due to halide migration to the contacts
- Encapsulated devices subjected to damp-heat 85% r.h./85°C degradation tests
- First tests show that adding an interlayer of polymer between NiO and PK improves stability (red and black curves



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