« Exchange of Experiences » - Webinar

Insights, outcomes and results – 28 September 2023

“PERDRY”
Dry production routes for large-area benign metal halide perovskite solar cells

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Partners:

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2) Bar Ilan University, David Cahen
3) Solmates BV, Mathijn Dekkers
4) Karlstad University, Ellen Moons
5) Sticky Solar Power, Jonas Buddgård
6) Glava Energy Center AB, Magnus Nilsson
7) 3G Solar, Barry Green

Scientific, technical, commercial challenge(s) addressed

PerDry aimed at:

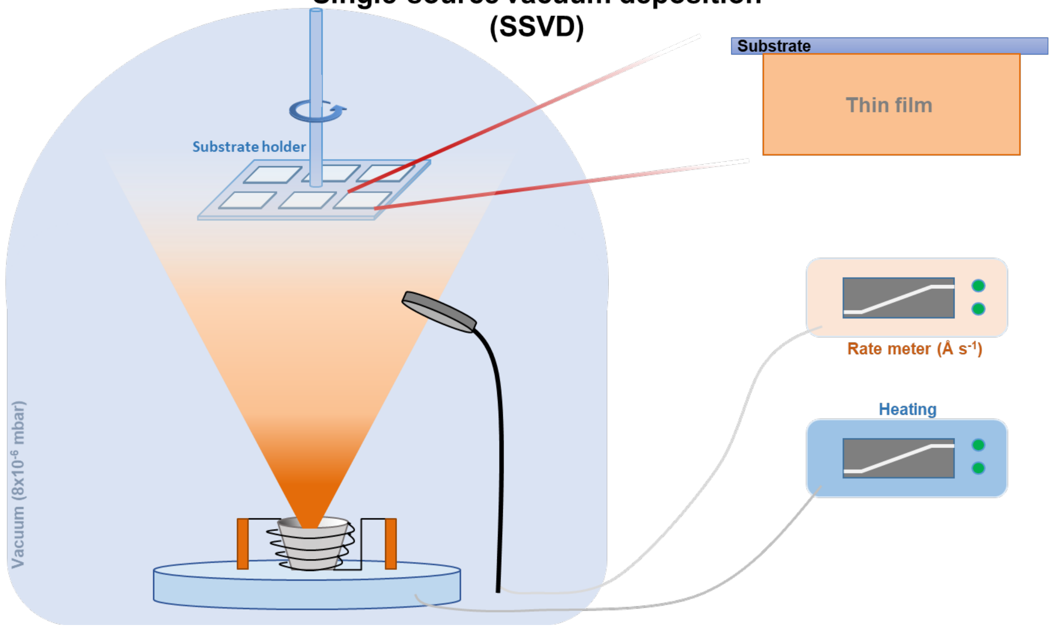
1. Developing scalable dry production technologies for thin film perovskite production, that can be integrated into industrial cell fabrication

2a. Developing benign Pb-free or -poor perovskites and integrate them into solar cells ***OR***

2b. Ensuring end-of-life protocol/encapsulation to prevent Pb to reach the environment, in case of module damage/leaching out of Pb.

3. Scaling up the deposition area to 100 cm^2 (PCE>19 %) using industrial tools and evaluate in outdoor conditions to show feasibility of the technology.

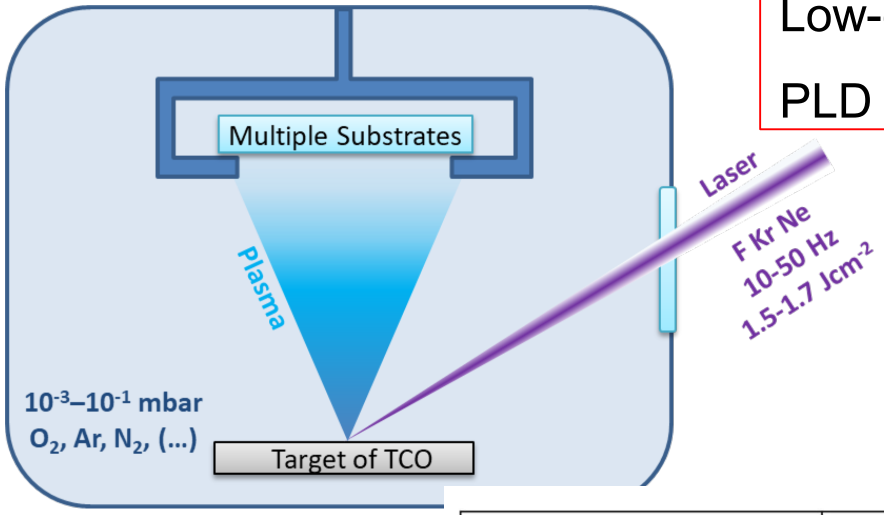
1.Develop scalable dry production technologies to deposit thin films from preformed Perovskite powders



Continuous feeding system for SSVD

Patent application submitted for new method by University of Valencia

Pulsed Laser Deposition (PLD)



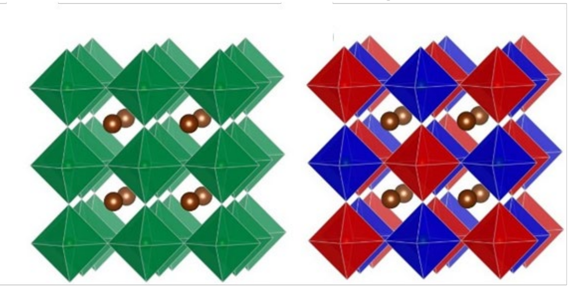
Low-cost laser for PLD systems

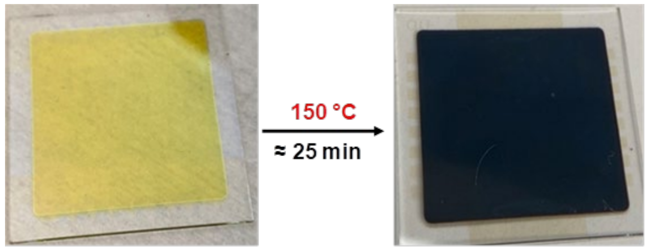
Conventional PLD	Our Approach
150,000 -300,000 USD  https://www.coherent.com/lasers/excimer	30-50 USD 

2a. Developing benign Pb-free or -poor perovskites and integrate them into solar cells

SnPb perovskites with bandgap 1.28 eV enables solar cells with PCE of 14 %.

$FAPb_{0.5}Sn_{0.5}I_3$: A Narrow Bandgap Perovskite Synthesized through Evaporation Methods for Solar Cell Applications **Sol RRL.**, 4, 2, 1900283 (2019).

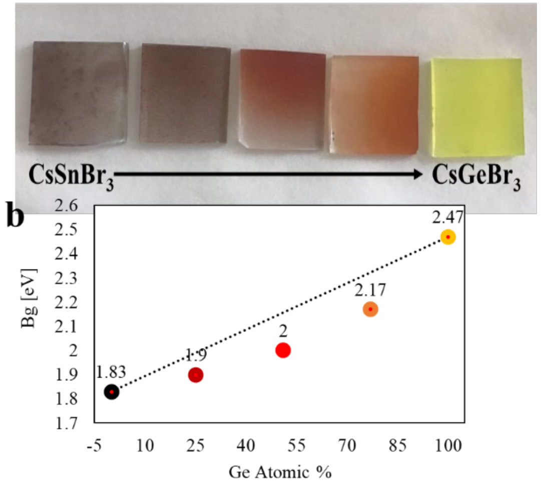


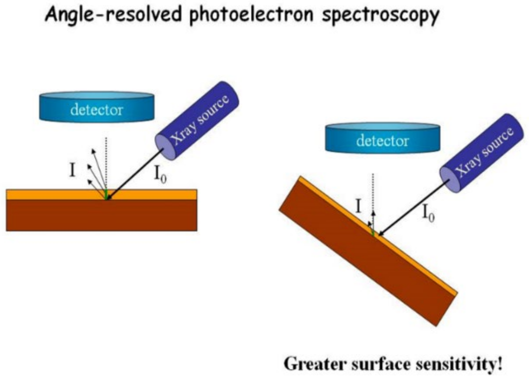


B-β $CsSnI_3$ forms

Several double perovskites were developed successfully, but di not lead to efficient PV cells

Tuning the Optical Absorption of Sn-, Ge-, and Zn-Substituted Cs2AgBiBr6 Double Perovskites: Structural and Electronic Effects. **Chem. Mater.**, 33, 20, 8028–8035 (2021) Pulsed Laser Deposition of Cs2AgBiBr6: from Mechanochemically Synthesized Powders to Dry, Single-Step Deposition. **Chem. Mater.**, 33, 18, 7417–7422 (2021)



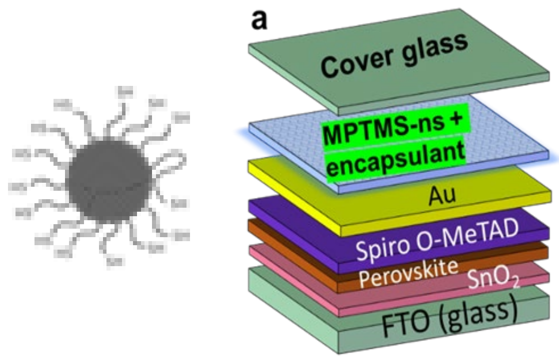


Ge containing perovskite were successfully prepared and characterized

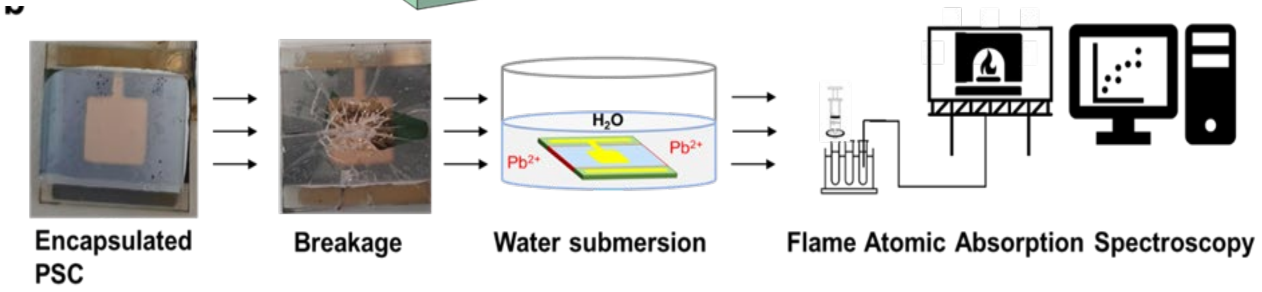
Adi Kama, Shivam Singh, E. Moons, D. Cahen manuscript in preparation

2b. Ensuring end-of-life protocol/encapsulation to prevent Pb to reach the environment, in case of module damage/leaching out of Pb.

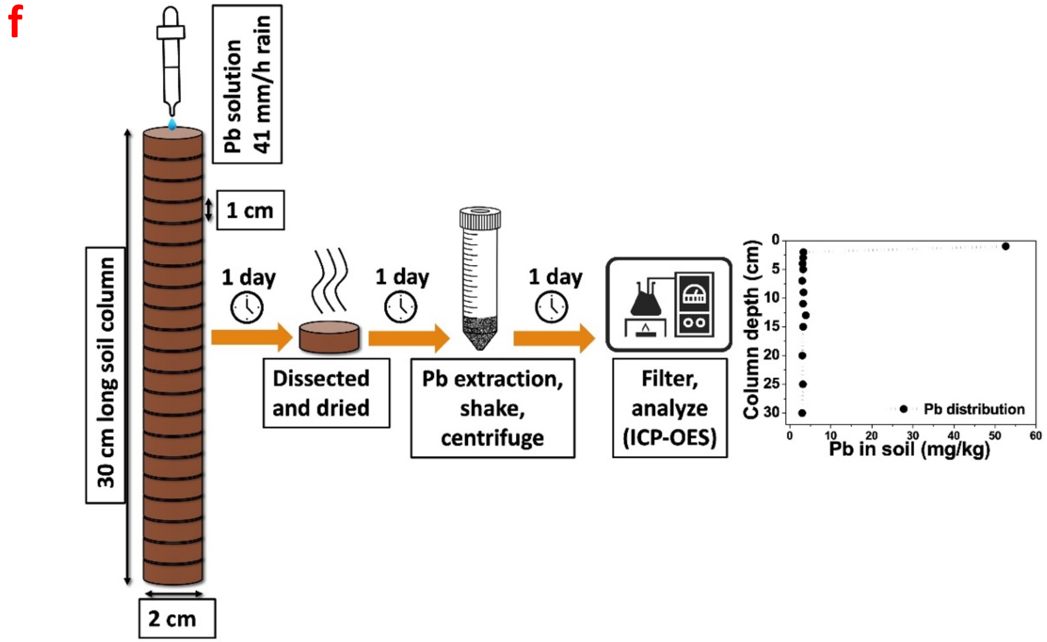
Thiol modified SiO_2 nanoparticles as low cost encapsulant and lead scavengers



Lead leaching reduced by 90% and no effect on cell efficiency

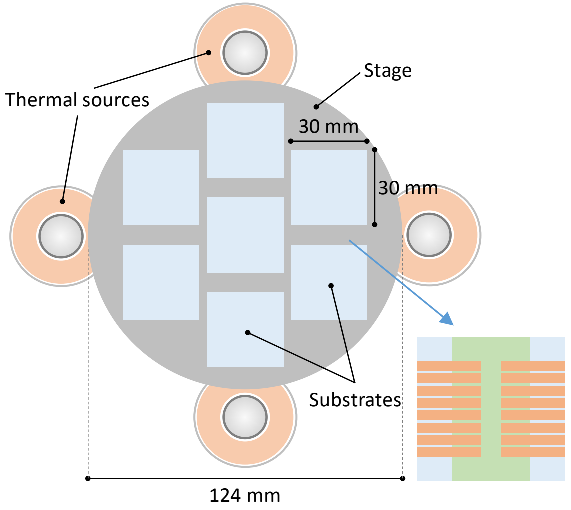


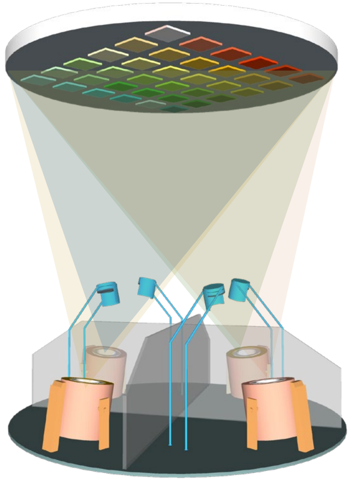
Mendez et al. *ACS Appl. Mater. & Interf. 14 (2022) 29766–29772*, Mallick, Mendez et al., *J Hazard. Mater., 451 (2023) 131147*

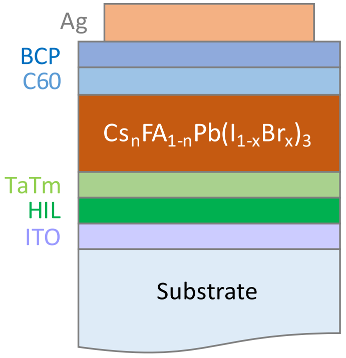


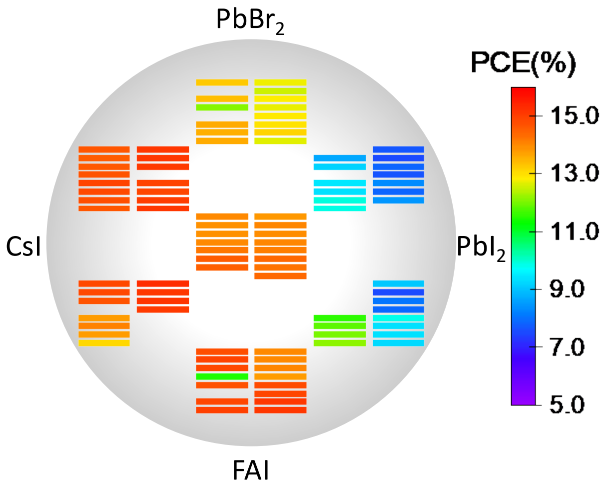
Lead solutions (20 mg/L, corresponding to an hour of heavy rain on a cell of 3 cm^2) are added to a column of soil. 99% of Lead is retained in first cm (only just above critical conc of 5 mg/L). Below that first cm negligible values of lead detected.

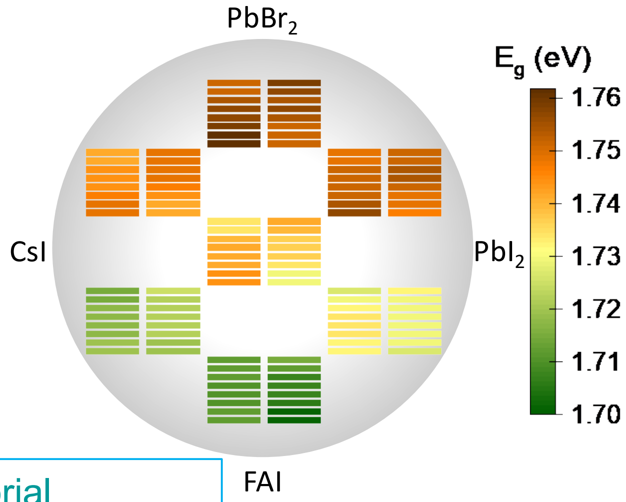
Characterization











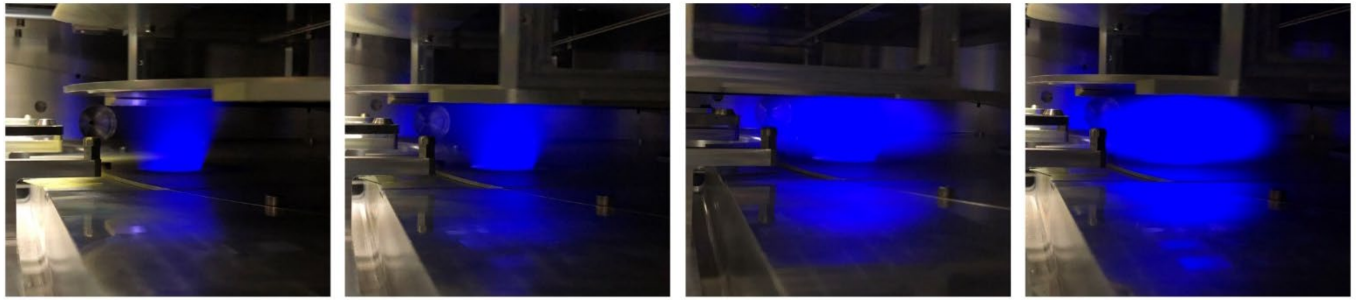
Very successful interaction between University of Valencia and Bar Ilan University. Combinatorial approach to deposition of perovskite films and devices. Enables fast identification of optimal composition for device performance with link to key material properties.

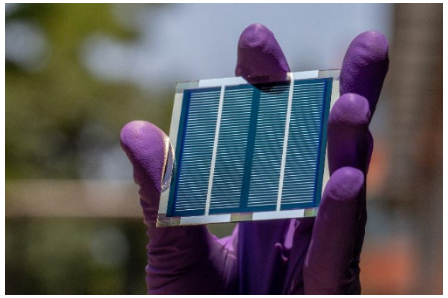
I. Susic, A. Kama, L. Gil-Escrig, C. Dreessen, F. Palazon, D. Cahen, M. Sessolo, H. J. Bolink. Combinatorial Vacuum-Deposition of Wide Bandgap Perovskite Films and Solar Cells. ***Adv. Mater. Interfaces*** *10, 2202271* (2023)

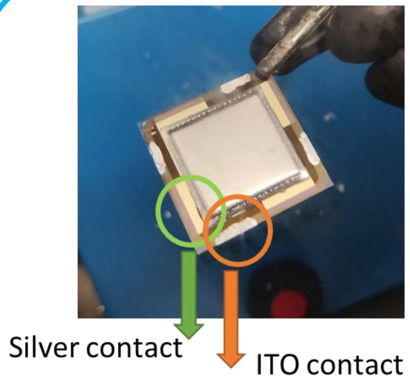
3. Scaling up the deposition area to 100 cm² (PCE>19 %) using industrial tools and evaluate in outdoor conditions to show feasibility of the technology.

We used large cells and modules to increase active area. Cells with 25 cm2 have been prepared with 14 % PCE (mainly hindered by low FF). This was enables by the soft deposition of top TCOs using PLD tool from our partner SOLMATES. Further improvements can be reached by screen printed grid lines.

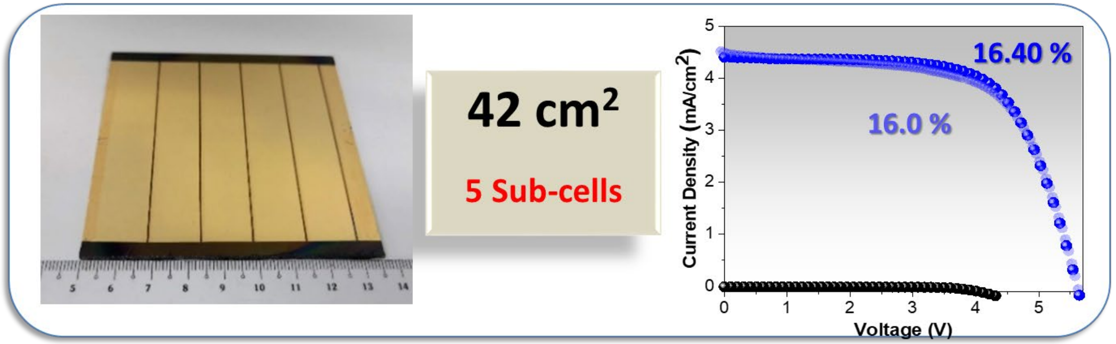
0.007 mbar | 0.033 mbar | 0.062 mbar | 0.100 mbar



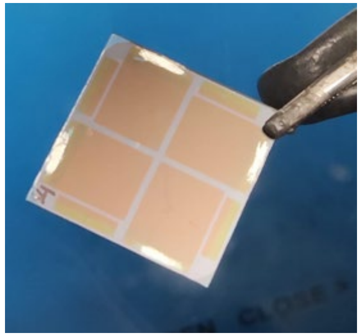




Modules (5 cells in series) of 42 cm² with PCE of 16.4 % have been made.



Cells encapsulated for outdoor testing at our partner Glava Energy Center AB
One cell still working after 6 months!!



Experiences gained in transnational set-up
Critical factors and lessons learned for future successful transnational R&I projects

- Successful international interaction, leading to 1 patent and > 10 scientific publications
- Covid pandemic hindered physical meetings but emerge of online meetings have made interactions stronger
- Different time lines at different countries (starting and ending dates, reporting deadlines) makes alignment of priorities difficult and increases the coordinators (administrative) burden.
- For future successful transnational R&I projects:
  - Ensure Budgets in line with tasks (in PERDRY not the case, due to national budget restrictions of some participating countries).
  - Try to align the reporting at ERANET level which is passed on to the national funding agencies. (no double reporting)
  - Try to align budget rules over the different funding agencies.
  - Helpful if some of the project partners have had previous collaborations.