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Johnpaul, Kurisinkal-Pious

ETHZ: Chih-Jen Shih, Sudhir
Kumar, Sunil Benachigere
Shivarudraiah

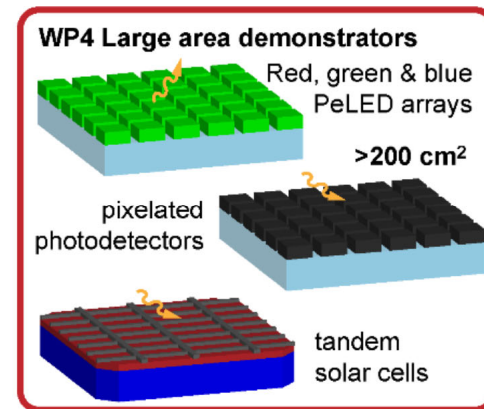
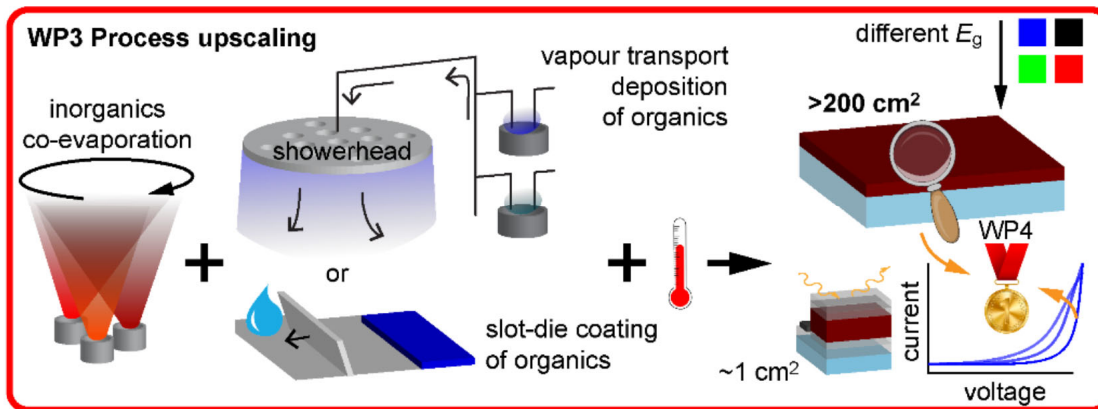
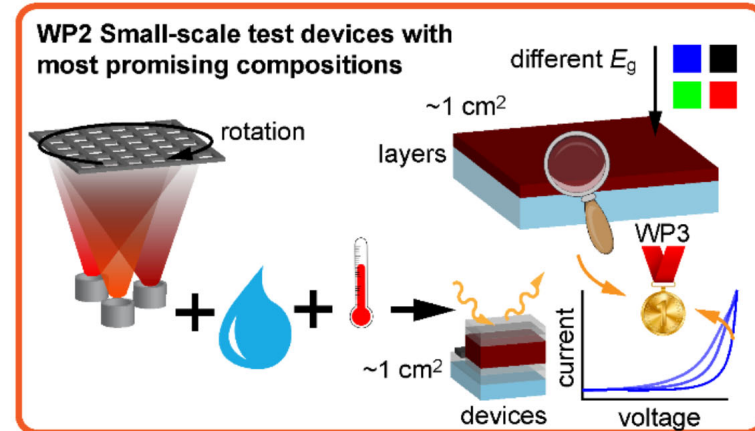
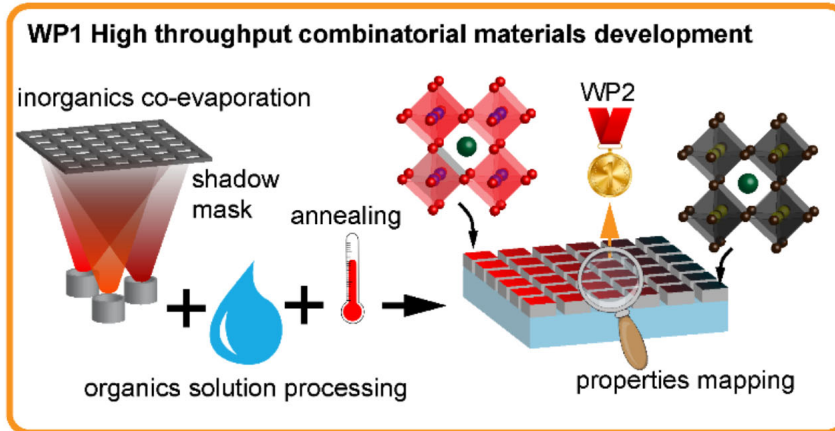
Empa CT: Sebastian Siol,
Alexander Wieczorek

AMYS - Advancing manufacturability of hybrid organic-inorganic semiconductors for large area optoelectronics

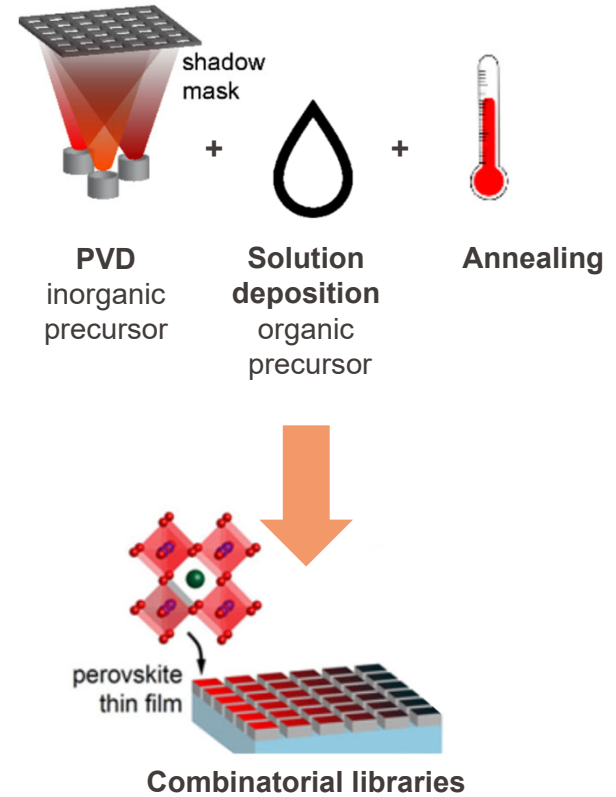
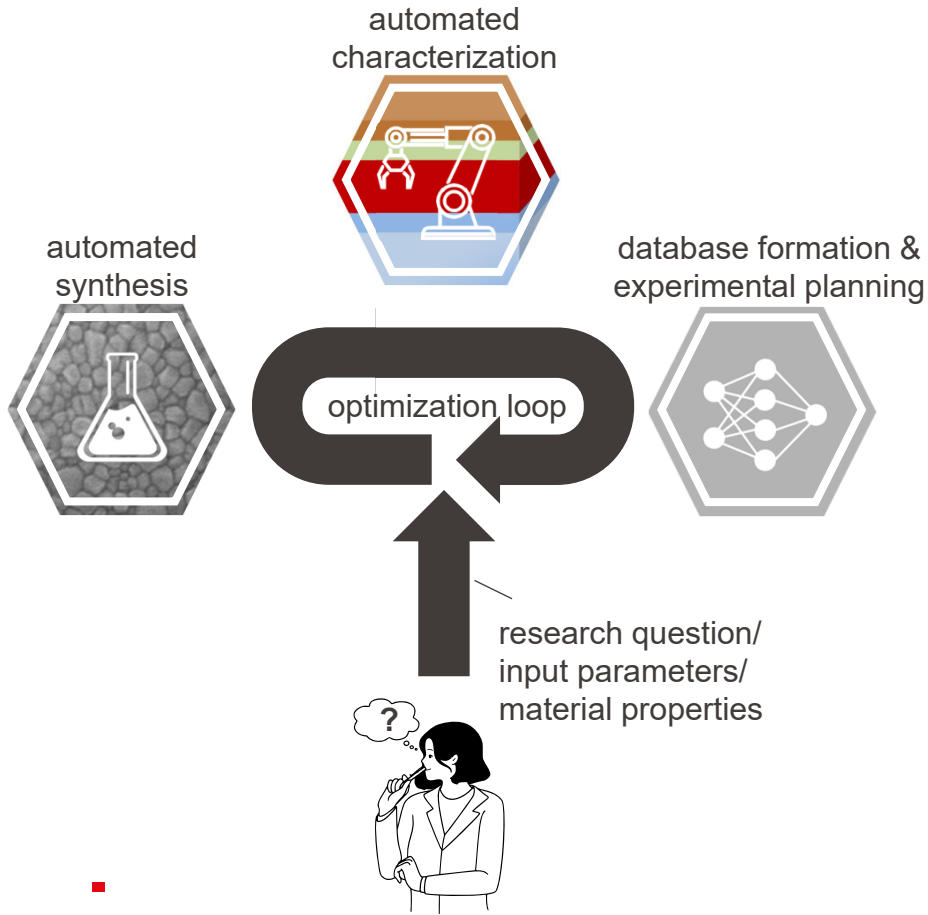
SFA AM Review
Meeting 2023

14.02.2024

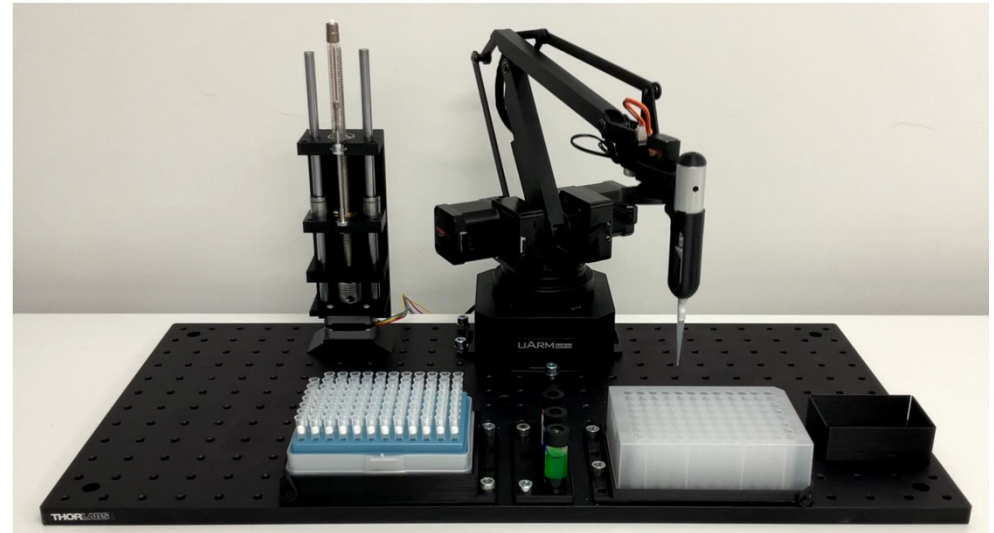
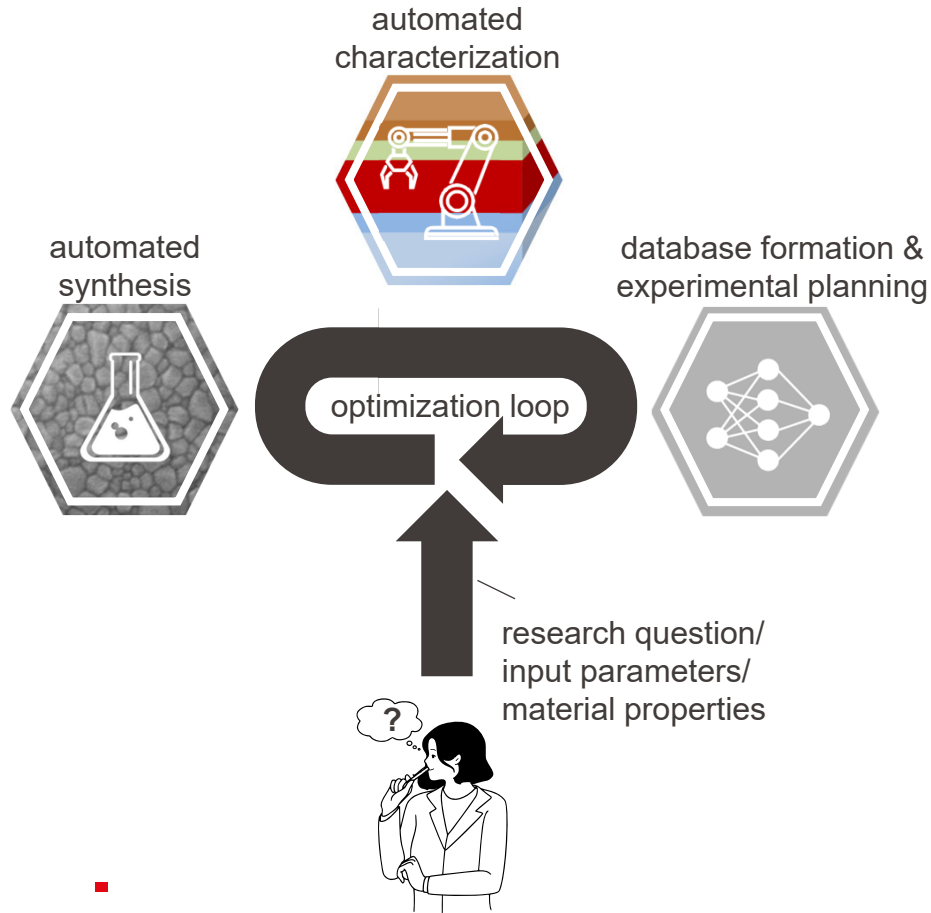
general scope



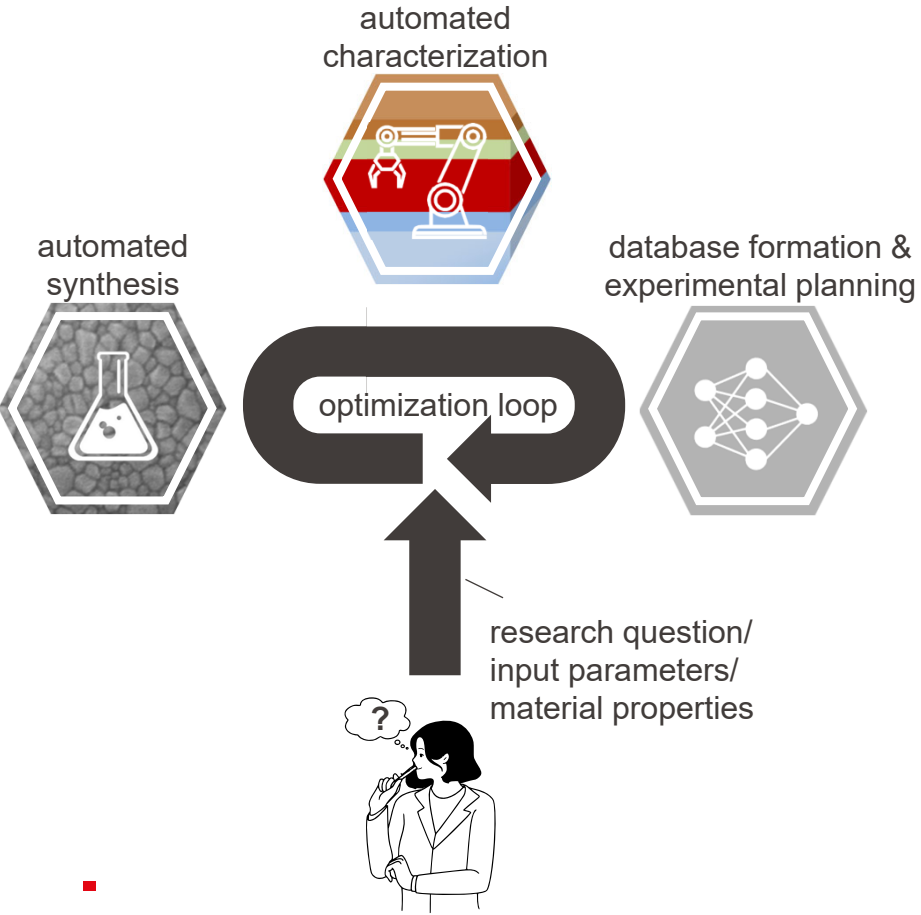
WP1: Perovskite library preparation & characterization



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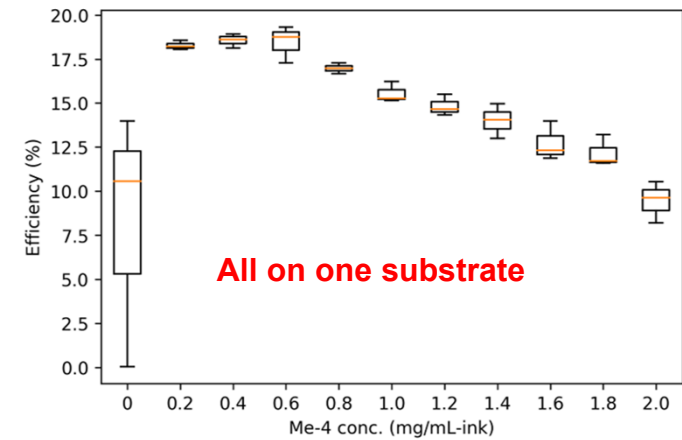


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WP1 : Accelerated screening of known «perovskites»



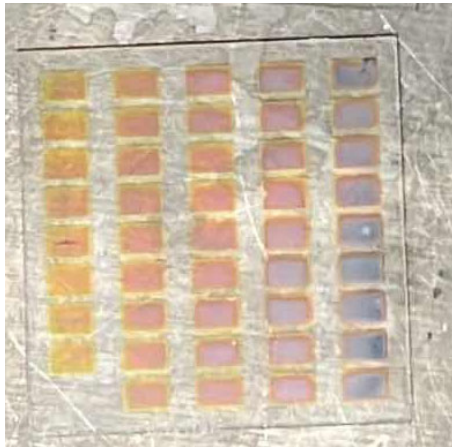
Example of a one-shot optimization:



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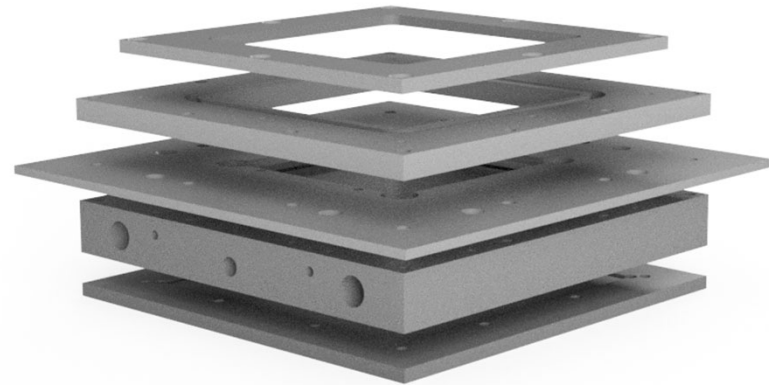
WP1 : Accelerated analysis

High-throughput optical screening



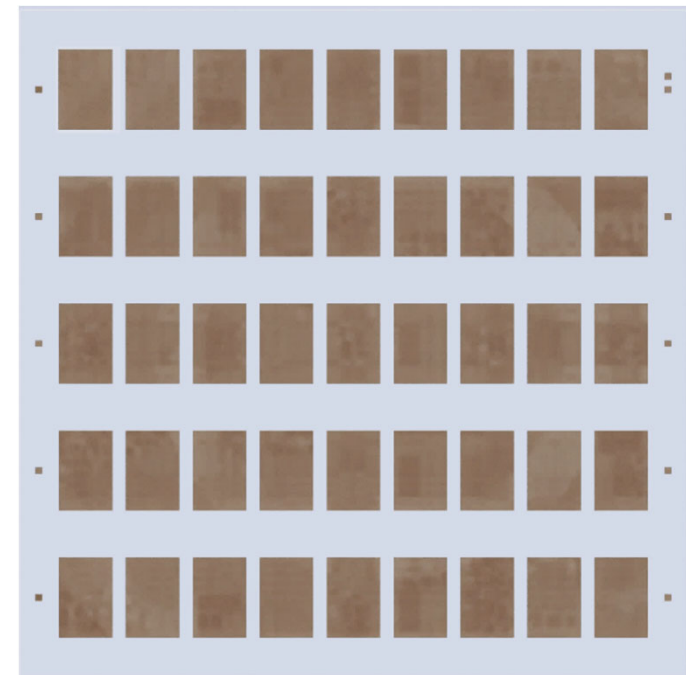
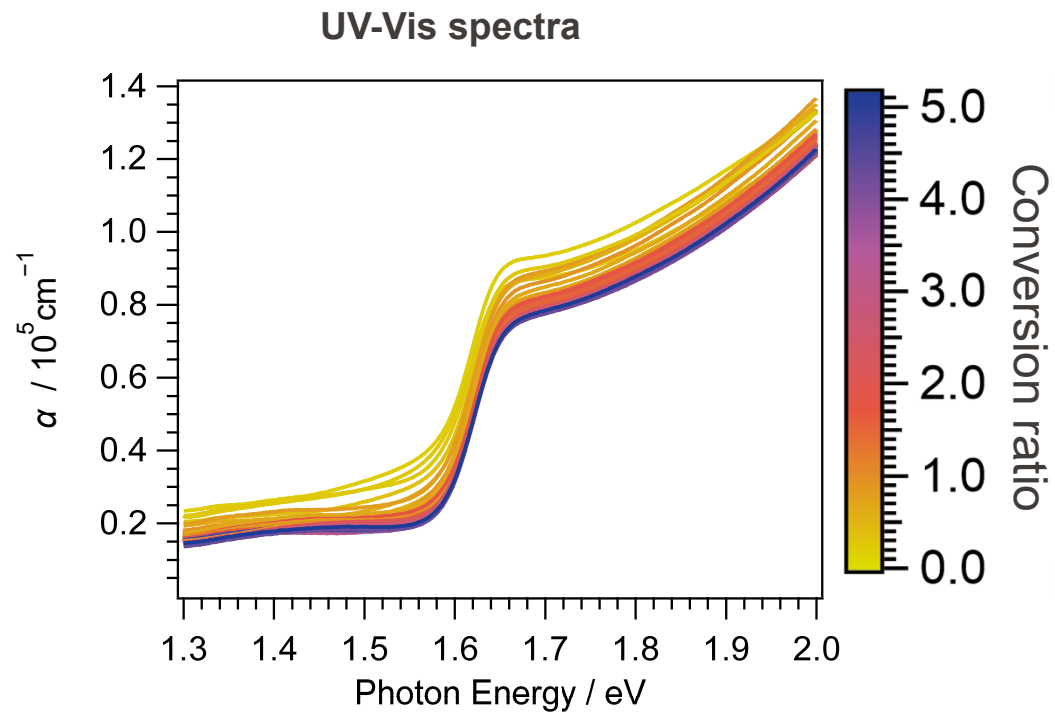
- Screening of transmittance, reflectance demonstrated.
- Additional: XRF, 2D-XRD

+ Stability screening



- In-situ degradation studies
 - Elevated temperatures
 - Increased illumination
 - Reactive environments

WP2: Optical properties of pristine perovskites for tandems

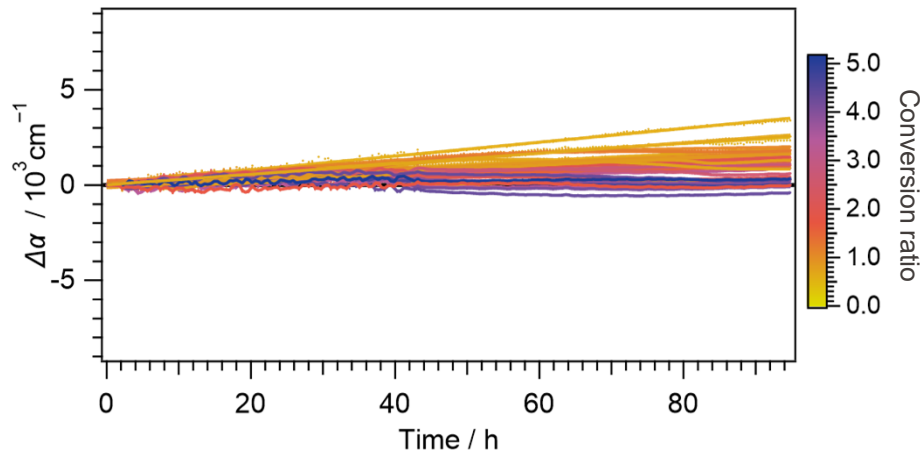


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A Wieczorek, AG Kuba, J Sommerhäuser, LN Caceres, CM Wolff, S Siol - Journal of Materials Chemistry A, 2024

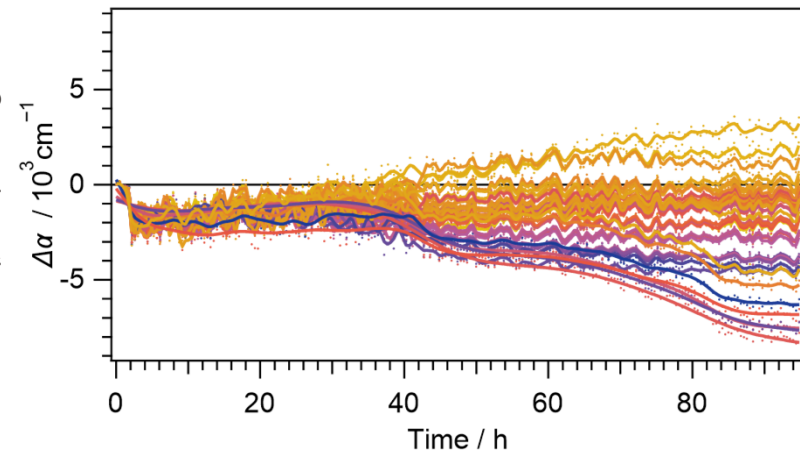
WP2: Optical changes during aging

Absorption changes below bandgap (1.4 eV)



- $\Delta\alpha$ increase
 - Increased optical scattering

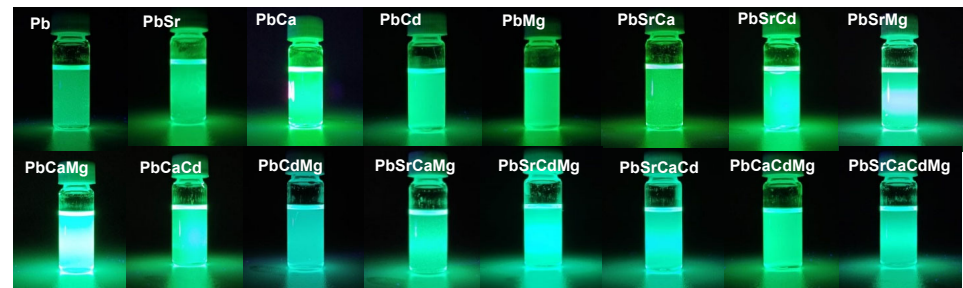
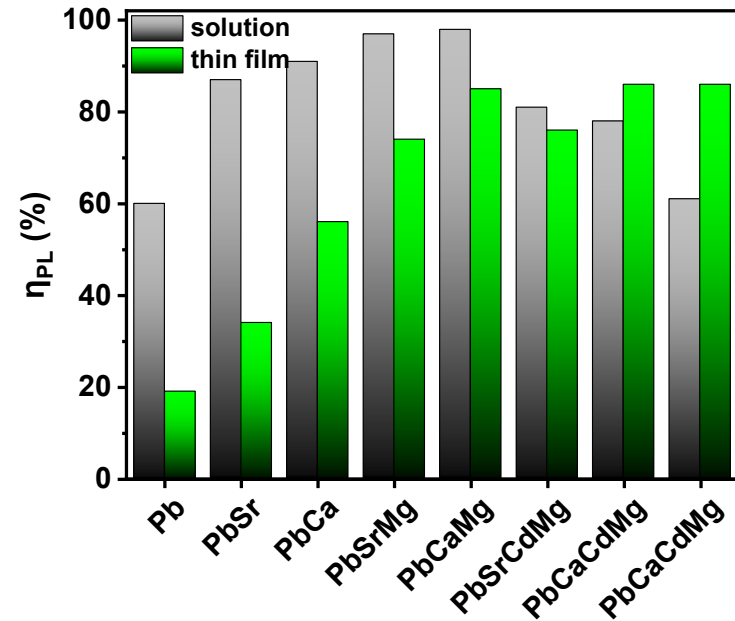
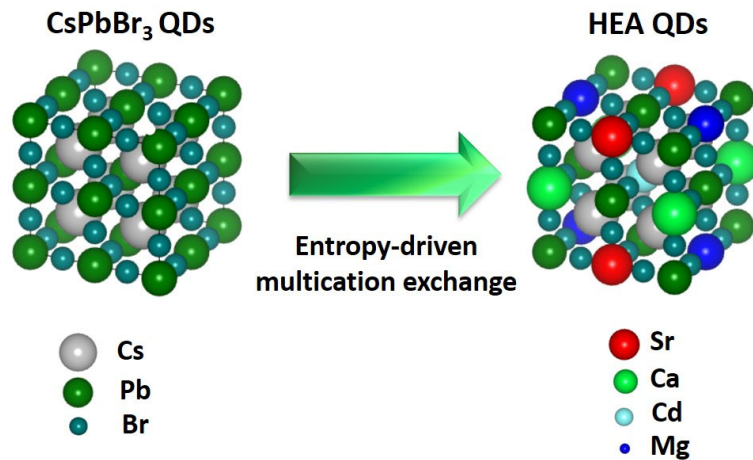
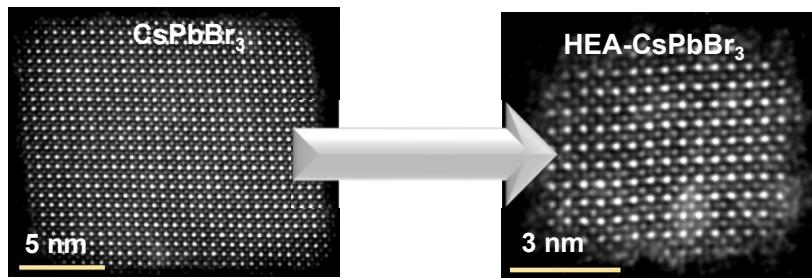
Absorption changes above bandgap (1.7 eV)



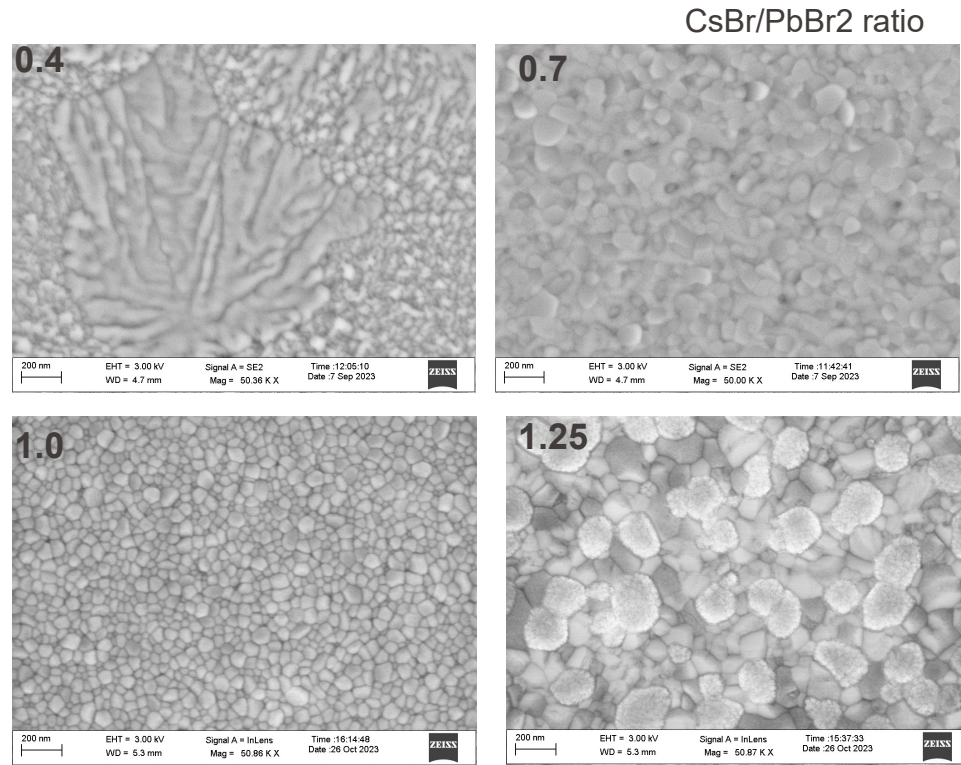
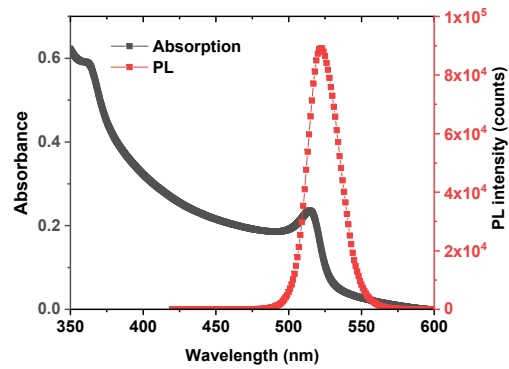
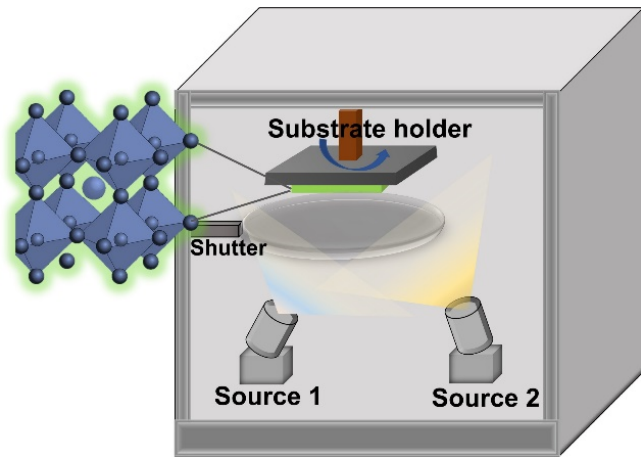
- $\Delta\alpha$ increase & decrease
 - Increase: optical scattering
 - Decrease: Loss of perovskite

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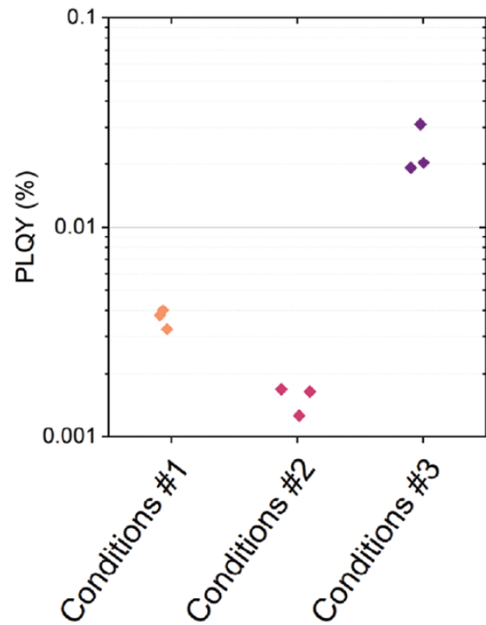
WP2: High Entropy Alloyed Nanocrystals for Light Emission



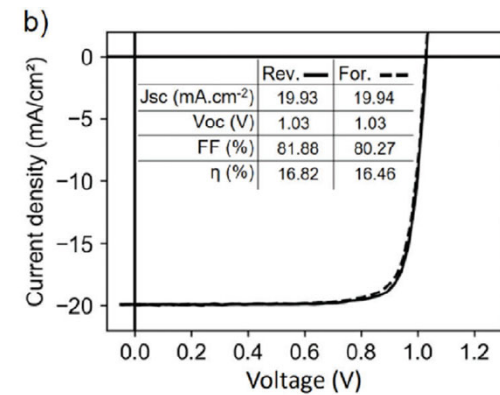
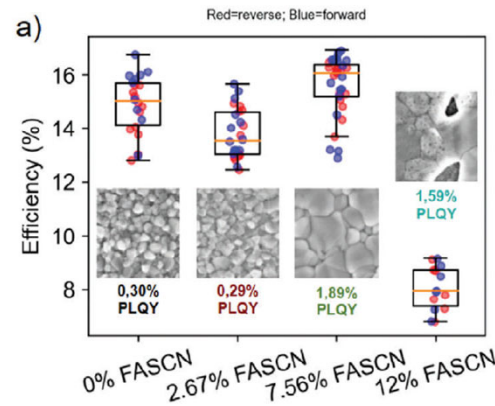
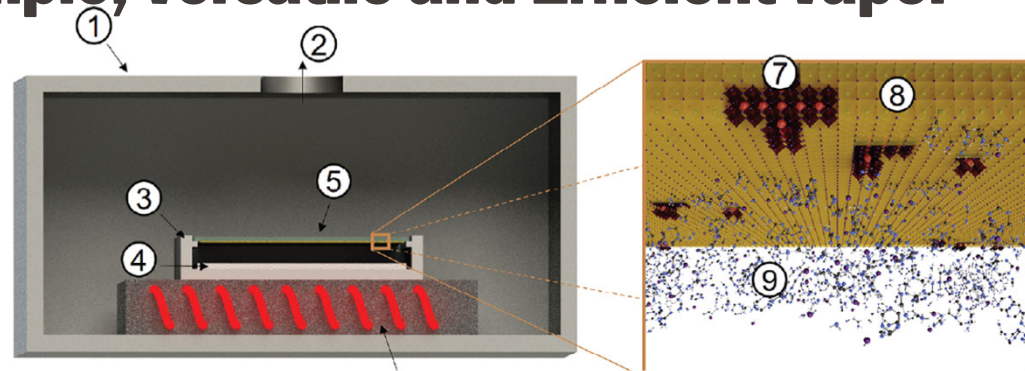
WP2: Vapor-deposited perovskite LEDs



WP2: Pizza Oven Processing of Organohalide Perovskites(POPOP): A Simple, Versatile and Efficient Vapor Deposition Method



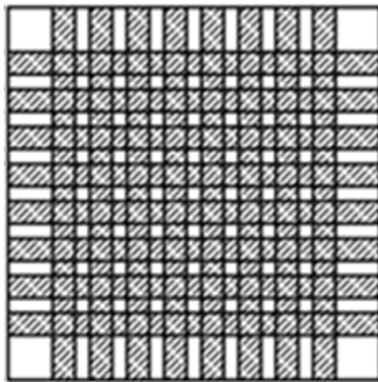
Sublimation + right Conditioning → control of Growth → High quality Solar cells



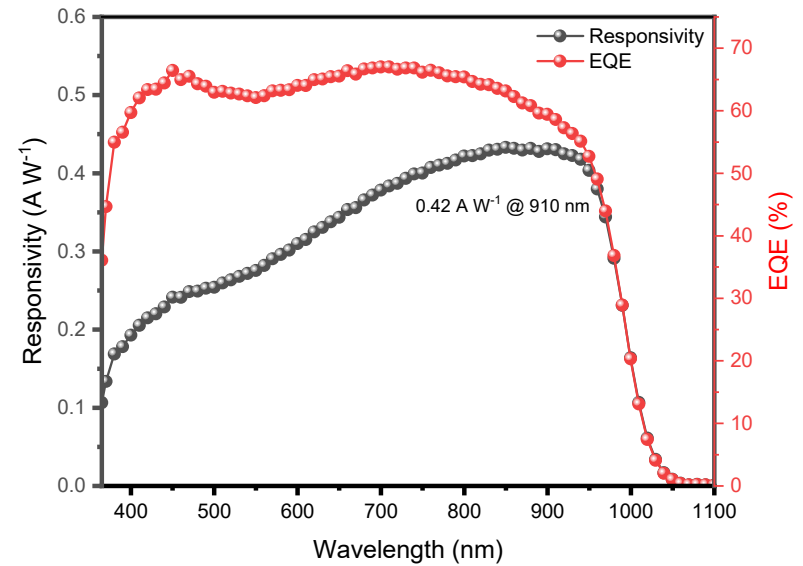
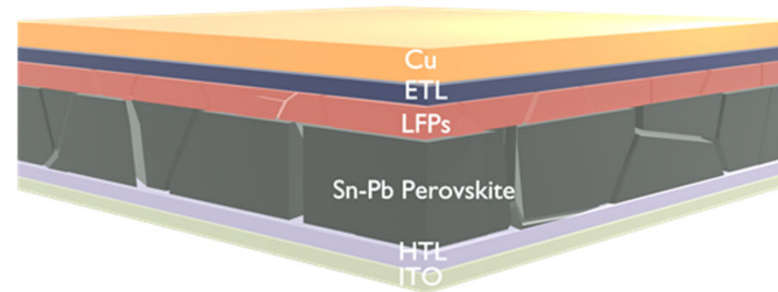
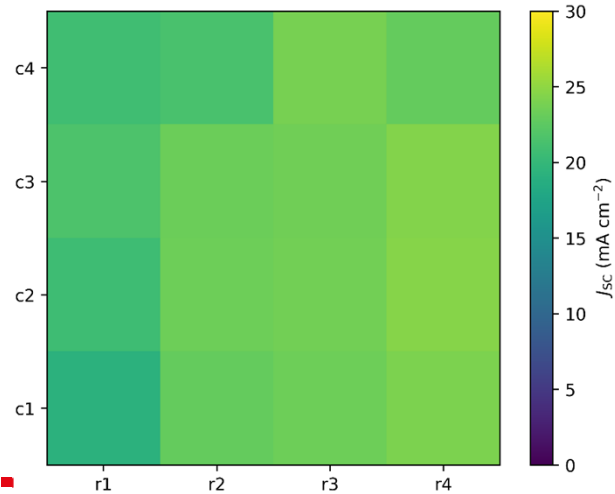
■ Q. Guesnay et al. Adv. Energy Mater.2024, 2303423 DOI: 10.1002/aenm.202303423

WP3: Blade-coated Photodetector Aarray

Bottom ITO electrode



Top Cu electrode



Conclusions

- Unique automated Fabrication, Characterization, Aging platforms for all sets of samples
- Enhanced controlled for growth and microstructure with various techniques
- Small- and large-scale devices developed (LEDs, Photodetector arrays, Tandem Solar Cells) – among the best in the world

And many collaborative papers!

Alexander Wiczorek , Austin George Kuba , Jan Sommerhäuser , Luis Nicklaus Caceres , Christian Michael Wolff and Sebastian Siol, Advancing High-Throughput Combinatorial Aging Studies of Hybrid Perovskite Thin-Films via Precise Automated Characterization Methods and Machine Learning Assisted Analysis, 10.1039/D3TA07274F (Paper) J. Mater. Chem. A, 2024

Siarhei Zhuk, Alexander Wiczorek, Amit Sharma, Jyotish Patidar, Kerstin Thorwarth, Johann Michler, and Sebastian Siol, Combinatorial Reactive Sputtering with Auger Parameter Analysis Enables Synthesis of Wurtzite Zn₂Ta₃N₃, Chem. Mater. 2023, 35, 17, 7069–7078

Quentin Guesnay, Charles J. McMonagle, Dmitri Chernyshov, Waqas Zia, Alexander Wiczorek, Sebastian Siol, Michael Saliba, Christophe Ballif, and Christian M. Wolff, Substoichiometric Mixing of Metal Halide Powders and Their Single-Source Evaporation for Perovskite Photovoltaics, ACS Photonics 2023, 10, 9, 3087–3094

Quentin Guesnay, Florent Sahli, Kerem Artuk, Deniz Turkay, Austin G. Kuba, Nada Mrkyvkova, Karol Vegso, Peter Siffalovic, Frank Schreiber, Huagui Lai, Fan Fu, Martin Ledinský, Nicolas Fürst, Aymeric Schafflützel, Cédric Bucher, Quentin Jeangros, Christophe Ballif, Christian M. Wolff, Pizza Oven Processing of Organohalide Perovskites (POPOP): A Simple, Versatile and Efficient Vapor Deposition Method, Advanced Energy Materials, 2024

Alexander Wiczorek, Huagui Lai, Johnpaul Pious, Fan Fu, Sebastian Siol, Resolving Oxidation States and X-site Composition of Sn Perovskites through Auger Parameter Analysis in XPS, Adv. Mater. Interfaces 2023, 10, 2201828.

Huagui Lai, Jincheng Luo, Yannick Zwirner, Selina Olthof, Alexander Wiczorek, Fangyuan Ye, Quentin Jeangros, Xinxing Yin, Fatima Akhundova, Tianshu Ma, Rui He, Radha K. Kothandaraman, Xinyu Chin, Evgeniia Gilshtein, André Müller, Changlei Wang, Jarla Thiesbrummel, Sebastian Siol, José Márquez Prieto, Thomas Unold, Martin Stolterfoht, Cong Chen, Ayodhya N. Tiwari, Dewei Zhao, Fan Fu, High-Performance Flexible All-Perovskite Tandem Solar Cells with Reduced VOC-Deficit in Wide-Bandgap Subcell, Adv. Energy Mater. 2022, 12, 2202438

K. Suchan, T. J. Jacobsson, C. Rehermann, E. L. Unger, T. Kirchartz, C. M. Wolff, Rationalizing Performance Losses of Wide Bandgap Perovskite Solar Cells Evident in Data from the Perovskite Database. Adv. Energy Mater. 2024, 14, 2303420

Johnpaul Kurisinkal Pious, Yannick Zwirner, Huagui Lai, Selina Olthof, Quentin Jeangros, Evgeniia Gilshtein, Radha K Kothandaraman, Kerem Artuk, Philipp Wechsler, Cong Chen, Christian M Wolff, Dewei Zhao, Ayodhya N Tiwari, Fan Fu, Revealing the role of tin fluoride additive in narrow bandgap Pb-Sn perovskites for highly efficient flexible all-perovskite tandem cells, ACS Applied Materials & Interfaces, 2023