Perovskite-Silicon Tandem Solar Cells by Scalable Spray Coating Process

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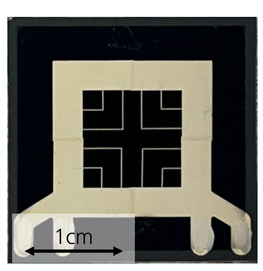
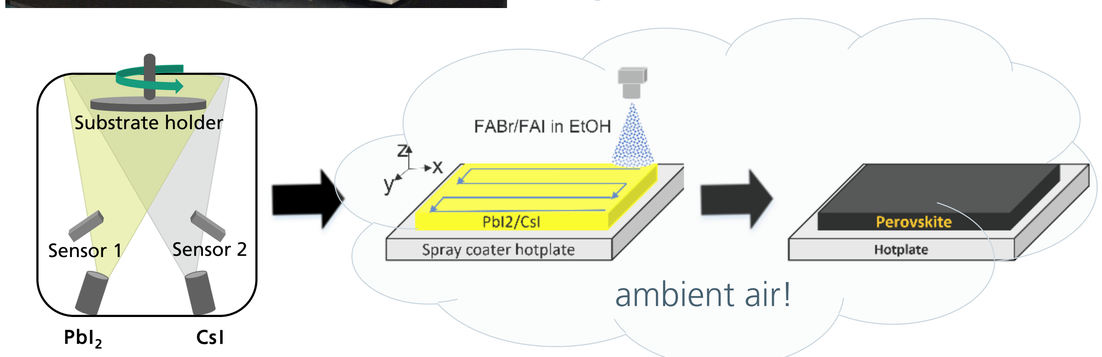
Introduction

- Hybrid process: thermally evaporated PbI_2/CsI on **fully textured** silicon heterojunction (SHJ) bottom solar cells
- Table top spray coater: ultrasonic nozzle, **operates in ambient air**
- First sprayed tandem solar cell η = 18.8%, in this work improved to 20.7%

Left: Custom table top spray coater by the company Eqiosonics

Right: Perovskite/silicon tandem solar cell processed by spray coating





Sketch: co-evaporation of inorganic compunds, spray coating of organic solution, thermal annealing

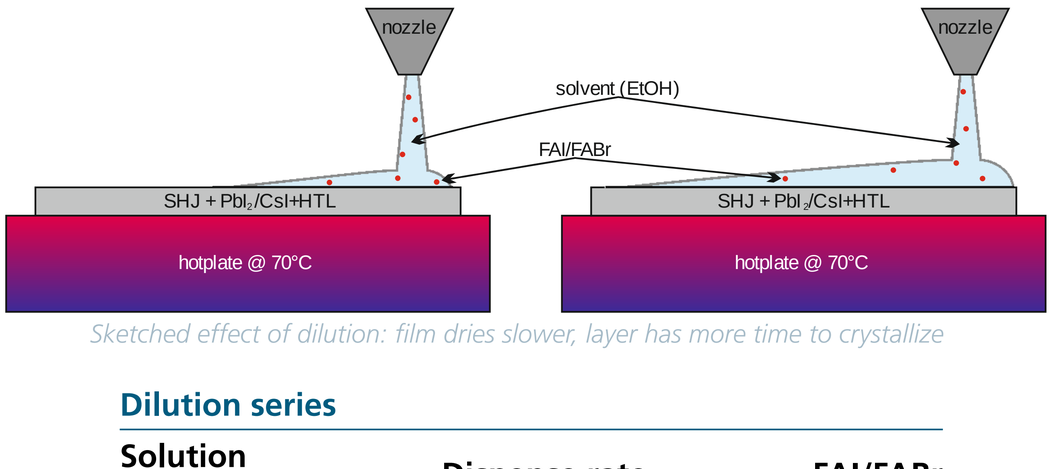
Experimental Approach

Spray process

Substrate: SHJ bottom cell with spin coated hole transport layer (HTL) + evaporated PbI_2/CsI scaffold (≈500 nm)

Substrate temperature: 70°C

Sprayed solution: FAI/FABr in EtOH (varied molarity)



Sketched effect of dilution: film dries slower, layer has more time to crystallize

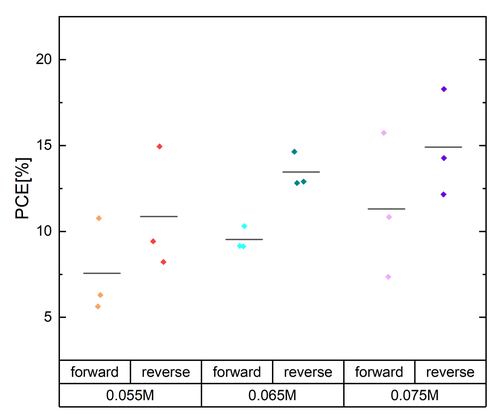
Dilution series

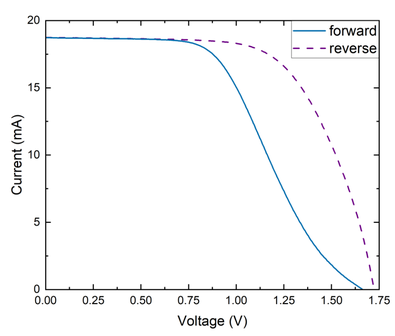
Solution concentration	Dispense rate	FAI/FABr
0.075 M	8.9 µl/cm²	0.095 mg/cm²
0.065 M	10.3 µl/cm²	0.095 mg/cm²
0.055 M	12.2 µl/cm²	0.095 mg/cm²

Results

I-V Characterization

- Large spread observed, difficult to identify trends
- Best cell at 18.3% after light soaking (20 min): **20.7%**
- Biggest limitation due to low *FF* (64%), strong hysteresis
- Spin coating ref. (after light soaking): 20.7% (fabricated via hybrid route)

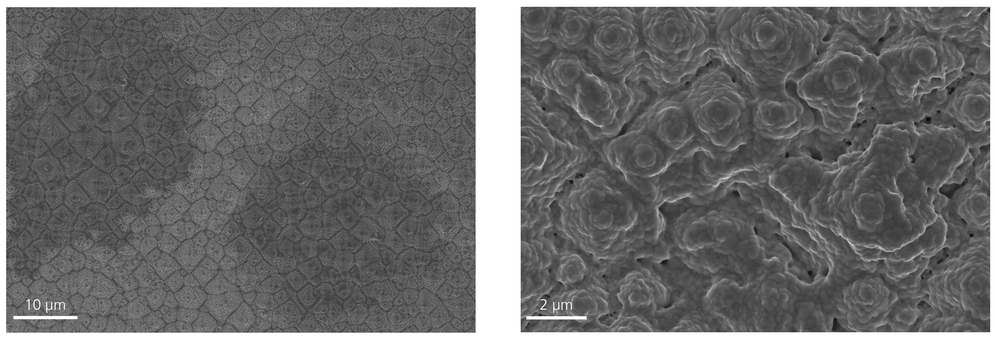




Left: I-V results of dilution series. Right: I-V curve of best cell (after 20 min. light soaking)

SEM characterization

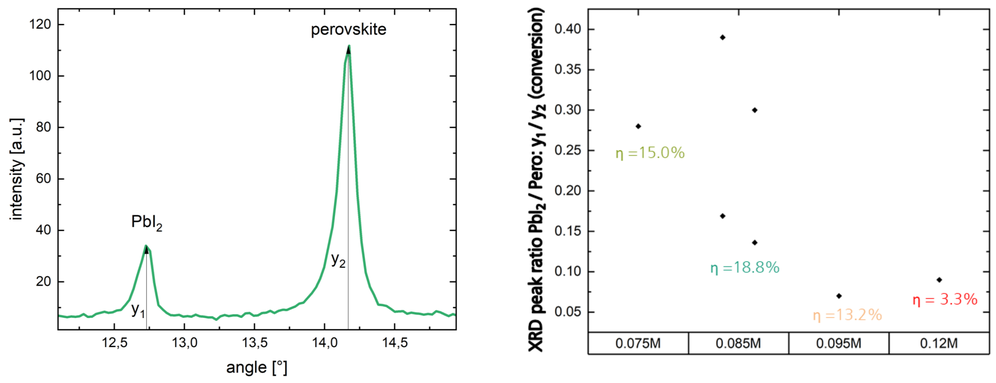
- Inhomogeneities in surface morphology observed



SEM top view images of different regions of sprayed perovskite/silicon tandem solar cell

XRD Characterization

- Conversion ratio calculated only used as indicator, affected by many factors!
- No clear trend visible: more complete conversion ≠ better cells



Left: exemplary XRD scan of sprayed perovskite absorber. Right: relation of conversion coefficient, molarity and efficiency

[1] https://www.finke.com/spraying-system.html

link to Fraunhofer ISE contributions of the 40th EU PVSEC (available as of 20.09.2023)

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