Perovskite Top Solar Cell Development for Monolithic Silicon-Based Tandem and Triple-Junction Solar Cell Application

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Introduction

- **Goal:** Reduce leveled costs of electricity by increasing efficiency with multijunction solar cells
- **Perovskite as partner for silicon enabling high efficiency, tunable bandgap, cheap fabrication
- **Presented:** Recent research on perovskite top solar cells for Si-based tandem and triple-junction devices

Monolithic Perovskite Silicon Tandem Solar Cells

- **Current Density >20 mA/cm² for Tandem Devices with Planar Front**
- **One-step spincoating route with solvent method**
- **Cs0.8(FA0.2)1.5PbI3Br0.05** with lead excess $\rightarrow 1.64$ eV
- **Flexible processing allows for fast material screenings**

Hybrid Route for Industrially Relevant Textured Tandems

- **Two-step hybrid co-evaporation/spincoating route**
- **FA0.8Cs0.2PbI3Br0.05** $\rightarrow 1.66$ eV
- **Conformal perovskite films on μm-sized textured Si for high energy yield potential**

Monolithic Perovskite Perovskite Silicon 3J Solar Cells

- **One-step spincoating route with antisolvent method for middle and adapted spincoating with gas quenching for top perovskite absorber**
- **Cs0.8FA0.2MA0.75Br0.05** with lead excess $\rightarrow 1.56$ eV and **Cs0.8FA0.2MA0.75Br0.05** with lead excess $\rightarrow 1.83$ eV
- **Triple-junction baseline for material screening established**

Recent Lab-Sized Tandem and Triple-Junction Solar Cell Results at Fraunhofer ISE (Forward and Reverse Scan)

Device Type | Area [cm²] | $V_{OC}$ [V] | $J_{SC}$ [mA/cm²] | FF [%] | PCE [%] | Stab. PCE [%]
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Perovskite silicon tandem junction solar cell (planar) | 0.25 d.a. | 1847 | 20.3 | 76.9 | 28.8 | 28.8
Perovskite silicon tandem solar cell (textured) | 1.0 d.a. | 1903 | 20.1 | 78.7 | 30.0 | 30.0
Perovskite silicon-triple-junction solar cell (planar) | 1.0 d.a. | 2862 | 8.9 | 79.1 | 20.1 | 20.0

Perovskite solar cell processing can be successfully adapted for the use on planar and industrially μm-sized textured silicon bottom solar cells for tandem and multi-junction application. Besides optimum choice of perovskites, opto-electrical optimization of selective contacts and electrodes is key to unlock the efficiency potential.

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