TROY TECHNICAL

PEROVSKITE SOLAR CELLS

WEEKLY REPORT

November 8 - November 14, 2026 | Issue 2026-W45

Bankable module performance, durability, manufacturing yield and market entry

9	9
ANALYZED ARTICLES	PRIORITY THEMES

Issued 2026-11-14 | English edition | fixed approved cover artwork



Perovskite Solar Cells: the boundary moved from isolated claims to qualification evidence

9 English articles were reviewed independently from the Japanese edition. Ten themes are retained for management decisions.

SIGNAL 01 | PRECURSORS

Tongwei Perovskite-Silicon Tandem: 2026 Production Roadmap

Tongwei has transitioned perovskite-silicon tandem cells from laboratory records to megawatt-scale validation, achieving a 210 half-cut cell efficiency of 33.09%.

SIGNAL 02 | CELL STACK

Perovskite Solar Cells: 22.7% Efficiency via Ambient Slot-Die Coating

Researchers from the Chinese Academy of Sciences and Dalian Maritime University achieved a 22.70% power conversion efficiency (PCE) in a 54.80 cm2 MA-free perovskite solar module using ambient slot-die coating.

SIGNAL 03 | MODULE PROCESS

Perovskite Solar Cells: Grain-Boundary Charge Balance and 26.55% Efficiency

Researchers from Hong Kong Polytechnic University and Zhejiang University have identified that uneven charge losses between neighboring crystal grains accelerate light-induced degradation in perovskite solar cells.

SIGNAL 04 | QUALIFICATION

Perovskite Mini-Modules: 23.9% Efficiency via Fill Factor Retention

Researchers have achieved a certified steady-state efficiency of 23.9% for a perovskite mini-module with a 19.48 cm2 aperture area.

DECISION

Focus this week's management attention on bankable module performance, durability, manufacturing yield and market entry. Move only when the linked evidence can be reproduced under your own operating conditions.

THREE MANAGEMENT MOVES

1. Buyers: compare certified performance with field-relevant lifetime, degradation and warranty evidence.
2. Suppliers: connect precursor and coating control to module yield, encapsulation, lead management and scale.
3. Executives: track stability, area, certification, yield, capex, lead control and warranty.

EVIDENCE DISCIPLINE

FACT states what the collected English source reports. BUSINESS READ and ACTION are editorial interpretations. UNKNOWN lists information that the source file does not establish. A linked article is not treated as independent confirmation of every claim.

Numbers and evidence anchors that require conditions

33.09%
A07

SOURCE-BOUND CONDITION
Tongwei has transitioned perovskite-silicon tandem cells from laboratory records to megawatt-scale validation, achieving a 210 half-cut cell efficiency of 33.09%.

22.70%
A03

SOURCE-BOUND CONDITION
Researchers from the Chinese Academy of Sciences and Dalian Maritime University achieved a 22.70% power conversion efficiency (PCE) in a 54.80 cm2 MA-free perovskite solar module using ambient slot-die coating.

26.55%
A04

SOURCE-BOUND CONDITION
By applying a chemical treatment to homogenize these losses, the team achieved a power conversion efficiency of 26.55% and maintained over 90% performance after 2,200 hours of continuous illumination.

23.9%
A08

SOURCE-BOUND CONDITION
Researchers have achieved a certified steady-state efficiency of 23.9% for a perovskite mini-module with a 19.48 cm2 aperture area.

35.1%
A02

SOURCE-BOUND CONDITION
Researchers at Soochow University have developed a perovskite-silicon tandem solar cell achieving a certified power conversion efficiency of 35.1%.

HOW TO USE THESE NUMBERS
Each value is shown with the condition stated in the collected English article. Do not compare values across different test methods, device sizes, operating temperatures or commercial stages without normalizing those conditions.

Where the value chain moved

Each stage combines one leading theme and one supporting theme. The report treats handoffs as evidence transfers, not decorative arrows.

1

Precursors

P01/P06

Tongwei has transitioned perovskite-silicon tandem cells from laboratory records to megawatt-scale validation, achieving a.

2

Cell stack

P02/P07

Researchers from the Chinese Academy of Sciences and Dalian Maritime University achieved a 22.70% power conversion efficiency.

3

Module process

P03/P08

Researchers from Hong Kong Polytechnic University and Zhejiang University have identified that uneven charge losses between.

4

Qualification

P04/P09

Researchers have achieved a certified steady-state efficiency of 23.9% for a perovskite mini-module with a 19.48 cm2 aperture.

5

Deployment & recycling

P05/P01

Researchers at Soochow University have developed a perovskite-silicon tandem solar cell achieving a certified power.

EVIDENCE REQUIRED AT EACH HANDOFF

Precursors to Cell stack	Transfer test conditions, acceptance criteria, failure data, owner and decision date. Recheck stability, area, certification, yield, capex, lead control and warranty.
Cell stack to Module process	Transfer test conditions, acceptance criteria, failure data, owner and decision date. Recheck stability, area, certification, yield, capex, lead control and warranty.
Module process to Qualification	Transfer test conditions, acceptance criteria, failure data, owner and decision date. Recheck stability, area, certification, yield, capex, lead control and warranty.
Qualification to Deployment & recycling	Transfer test conditions, acceptance criteria, failure data, owner and decision date. Recheck stability, area, certification, yield, capex, lead control and warranty.

COMMON CONTROL POINT

No theme moves to a commercial commitment until a named owner has reproduced the relevant evidence and documented stability, area, certification, yield, capex, lead control and warranty.

Priority map: maturity and next decision locus



P01	Tongwei Perovskite-Silicon Tandem: 2026 Production Roadmap Tech / process | cue: no system/business cue
P02	Perovskite Solar Cells: 22.7% Efficiency via Ambient Slot-Die Coating Tech / process | cue: no system/business cue
P03	Perovskite Solar Cells: Grain-Boundary Charge Balance and 26.55% Efficiency Tech / process | cue: no system/business cue
P04	Perovskite Mini-Modules: 23.9% Efficiency via Fill Factor Retention Tech / process | cue: no system/business cue
P05	Perovskite-Silicon Tandem Cells: 35.1% Efficiency for Space Use Tech / process | cue: no system/business cue
P06	Perovskite Solar Cells: Osaka University's AI-Robotic Fabrication System / adoption | cue: platform
P07	Perovskite Solar Cells: Taurine Application Extends Life 5x System / adoption | cue: Application
P08	Longi Perovskite-Silicon Tandem Cell: 35.31% Efficiency via SAMs Tech / process | cue: no system/business cue
P09	Gas-FE: Solvent-free perovskite deposition at >1 µm per minute Tech / process | cue: no system/business cue

REPRODUCIBLE POSITIONING RULE

Horizontal position uses five discrete stages: Research, Prototype, Joint evaluation, Product adoption and Scale. The vertical bands classify the next decision locus: Tech / process, System / adoption, or Business / rules (including supply systems). Article-title cues take precedence; the overview is used only when the title is silent. These are categories, not impact ranks. Bubble diameter reflects the editorial score.

FACT is source-bound. BUSINESS READ, ACTION and UNKNOWN are explicit editorial layers.

P01 Tongwei Perovskite-Silicon Tandem: 2026 Production Roadmap

A07 | Precursors | Product adoption

2026-11-12

FACT

Tongwei has transitioned perovskite-silicon tandem cells from laboratory records to megawatt-scale validation, achieving a 210 half-cut cell efficiency of 33.09%. By utilizing a "vapor deposition + solution two-step" process and a 5MW automated line, the company has reduced material costs by 60%.

WHY IT MATTERS

The decision relevance is bankable module performance, durability, manufacturing yield and market entry. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, connect precursor and coating control to module yield, encapsulation, lead management and scale.

ACTION

Within 30 days, compare certified performance with field-relevant lifetime, degradation and warranty evidence; record the evidence and owner against P01.

UNKNOWN

Still unproven or incompletely stated: stability, area, certification, yield, capex, lead control and warranty.

EDITORIAL SCORE 20/25 | MATURITY 4/5 | DECISION LOCUS: TECH / PROCESS

P02 Perovskite Solar Cells: 22.7% Efficiency via Ambient Slot-Die Coating

A03 | Cell stack | Joint evaluation

2026-11-13

FACT

Researchers from the Chinese Academy of Sciences and Dalian Maritime University achieved a 22.70% power conversion efficiency (PCE) in a 54.80 cm2 MA-free perovskite solar module using ambient slot-die coating. By utilizing two specific additives to extend the crystallization processing window to over 100 seconds, the team successfully produced uniform large-area thin films. This advancement addresses a critical bottleneck in transitioning from lab-scale spin-coating to scalable industrial manufacturing.

WHY IT MATTERS

The decision relevance is bankable module performance, durability, manufacturing yield and market entry. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, connect precursor and coating control to module yield, encapsulation, lead management and scale.

ACTION

Within 30 days, compare certified performance with field-relevant lifetime, degradation and warranty evidence; record the evidence and owner against P02.

UNKNOWN

Still unproven or incompletely stated: stability, area, certification, yield, capex, lead control and warranty.

EDITORIAL SCORE 20/25 | MATURITY 3/5 | DECISION LOCUS: TECH / PROCESS

FACT is source-bound. BUSINESS READ, ACTION and UNKNOWN are explicit editorial layers.

P03 Perovskite Solar Cells: Grain-Boundary Charge Balance and 26.55% Efficiency

A04 | Module process | Pilot

2026-11-10

FACT

Researchers from Hong Kong Polytechnic University and Zhejiang University have identified that uneven charge losses between neighboring crystal grains accelerate light-induced degradation in perovskite solar cells. By applying a chemical treatment to homogenize these losses, the team achieved a power conversion efficiency of 26.55% and maintained over 90% performance after 2,200 hours of continuous illumination.

WHY IT MATTERS

The decision relevance is bankable module performance, durability, manufacturing yield and market entry. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, connect precursor and coating control to module yield, encapsulation, lead management and scale.

ACTION

Within 30 days, compare certified performance with field-relevant lifetime, degradation and warranty evidence; record the evidence and owner against P03.

UNKNOWN

Still unproven or incompletely stated: stability, area, certification, yield, capex, lead control and warranty.

EDITORIAL SCORE 20/25 | MATURITY 2/5 | DECISION LOCUS: TECH / PROCESS

P04 Perovskite Mini-Modules: 23.9% Efficiency via Fill Factor Retention

A08 | Qualification | Pilot

Prior release 2026-11-06

FACT

Researchers have achieved a certified steady-state efficiency of 23.9% for a perovskite mini-module with a 19.48 cm2 aperture area. By utilizing a cryo-controlled processing step to preserve the fill factor, the team addressed efficiency losses typically associated with scaling from lab-scale devices to modules.

WHY IT MATTERS

The decision relevance is bankable module performance, durability, manufacturing yield and market entry. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, connect precursor and coating control to module yield, encapsulation, lead management and scale.

ACTION

Within 30 days, compare certified performance with field-relevant lifetime, degradation and warranty evidence; record the evidence and owner against P04.

UNKNOWN

Still unproven or incompletely stated: stability, area, certification, yield, capex, lead control and warranty.

EDITORIAL SCORE 20/25 | MATURITY 2/5 | DECISION LOCUS: TECH / PROCESS

FACT is source-bound. BUSINESS READ, ACTION and UNKNOWN are explicit editorial layers.

P05 Perovskite-Silicon Tandem Cells: 35.1% Efficiency for Space Use

A02 | Deployment & recycling | Pilot

2026-11-11

FACT

Researchers at Soochow University have developed a perovskite-silicon tandem solar cell achieving a certified power conversion efficiency of 35.1%. This technology matches the performance of expensive multi-junction GaAs cells while reducing estimated material costs to less than 1%.

WHY IT MATTERS

The decision relevance is bankable module performance, durability, manufacturing yield and market entry. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, connect precursor and coating control to module yield, encapsulation, lead management and scale.

ACTION

Within 30 days, compare certified performance with field-relevant lifetime, degradation and warranty evidence; record the evidence and owner against P05.

UNKNOWN

Still unproven or incompletely stated: stability, area, certification, yield, capex, lead control and warranty.

EDITORIAL SCORE 19/25 | MATURITY 2/5 | DECISION LOCUS: TECH / PROCESS

P06 Perovskite Solar Cells: Osaka University's AI-Robotic Fabrication

A06 | Precursors | Joint evaluation

2026-11-12

FACT

Researchers at the University of Osaka have developed an automated robotic platform integrated with machine learning to optimize perovskite solar cell fabrication in real time. The system achieved a power conversion efficiency of 24.4 percent by precisely controlling the crystallization process. This approach replaces conventional trial-and-error methods with a systematic protocol for improving thin-film quality.

WHY IT MATTERS

The decision relevance is bankable module performance, durability, manufacturing yield and market entry. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, connect precursor and coating control to module yield, encapsulation, lead management and scale.

ACTION

Within 30 days, compare certified performance with field-relevant lifetime, degradation and warranty evidence; record the evidence and owner against P06.

UNKNOWN

Still unproven or incompletely stated: stability, area, certification, yield, capex, lead control and warranty.

EDITORIAL SCORE 19/25 | MATURITY 3/5 | DECISION LOCUS: SYSTEM / ADOPTION

FACT is source-bound. BUSINESS READ, ACTION and UNKNOWN are explicit editorial layers.

P07 Perovskite Solar Cells: Taurine Application Extends Life 5x

A05 | Cell stack | Pilot

2026-11-12

FACT

Researchers have extended the lifespan of perovskite solar cells by five times by applying taurine, an antioxidant, to the interface between the metal oxide and perovskite layers. This method suppresses the degradation caused by superoxide radicals, maintaining over 95% of initial efficiency after 500 hours of continuous light exposure.

WHY IT MATTERS

The decision relevance is bankable module performance, durability, manufacturing yield and market entry. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, connect precursor and coating control to module yield, encapsulation, lead management and scale.

ACTION

Within 30 days, compare certified performance with field-relevant lifetime, degradation and warranty evidence; record the evidence and owner against P07.

UNKNOWN

Still unproven or incompletely stated: stability, area, certification, yield, capex, lead control and warranty.

EDITORIAL SCORE 19/25 | MATURITY 2/5 | DECISION LOCUS: SYSTEM / ADOPTION

P08 Longi Perovskite-Silicon Tandem Cell: 35.31% Efficiency via SAMs

A01 | Module process | Research

2026-11-10

FACT

Longi has achieved a power conversion efficiency of 35.31% in a perovskite-silicon tandem solar cell by utilizing engineered self-assembled molecules (SAMs). This molecular design optimizes charge transport and stability on textured surfaces, marking a significant advancement in high-efficiency photovoltaic architecture.

WHY IT MATTERS

The decision relevance is bankable module performance, durability, manufacturing yield and market entry. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, connect precursor and coating control to module yield, encapsulation, lead management and scale.

ACTION

Within 30 days, compare certified performance with field-relevant lifetime, degradation and warranty evidence; record the evidence and owner against P08.

UNKNOWN

Still unproven or incompletely stated: stability, area, certification, yield, capex, lead control and warranty.

EDITORIAL SCORE 19/25 | MATURITY 1/5 | DECISION LOCUS: TECH / PROCESS

FACT is source-bound. BUSINESS READ, ACTION and UNKNOWN are explicit editorial layers.

P09 Gas-FE: Solvent-free perovskite deposition at >1 µm per minute

A09 | Qualification | Pilot

2026-11-13

FACT

Researchers from ICMol and Oxford PV have developed gas flow assisted flash evaporation (Gas-FE), a solvent-free vacuum technique capable of depositing perovskite films at rates exceeding 1 µm per minute. By utilizing a pre-formulated powder aerosol, the method simplifies composition control and significantly reduces deposition time compared to conventional co-evaporation.

WHY IT MATTERS

The decision relevance is bankable module performance, durability, manufacturing yield and market entry. The signal should be tested at the application and operating-system level, not accepted from a headline alone.

BUSINESS READ

For operating companies, compare the reported change with current qualification, sourcing and product-roadmap assumptions. For suppliers, connect precursor and coating control to module yield, encapsulation, lead management and scale.

ACTION

Within 30 days, compare certified performance with field-relevant lifetime, degradation and warranty evidence; record the evidence and owner against P09.

UNKNOWN

Still unproven or incompletely stated: stability, area, certification, yield, capex, lead control and warranty.

EDITORIAL SCORE 19/25 | MATURITY 2/5 | DECISION LOCUS: TECH / PROCESS

Playbook and 0-5 year roadmap

STAKEHOLDER	NOW | 0-30 DAYS	NEXT | 1-12 MONTHS	LATER | 1-5 YEARS
Operating companies	compare certified performance with field-relevant lifetime, degradation and warranty evidence	Run production-like qualification with explicit acceptance and stop criteria.	Build a portfolio and architecture that can absorb technology and supplier changes.
Materials, equipment and technology suppliers	connect precursor and coating control to module yield, encapsulation, lead management and scale	Create shared reliability, process-window and failure-analysis data with customers.	Standardize interfaces, traceability, lifecycle support and recovery services.
Trading, investment and legal teams	Map stability, area, certification, yield, capex, lead control and warranty.	Contract for capacity, quality, change notice, liability, alternatives and exit.	Diversify regional, technical and customer concentration risk.

ROADMAP

NOW | 0-30 DAYS
Evidence ledger
Owner: Strategy + quality
Deliverable: claim, source, condition, owner

NOW | 0-30 DAYS
Risk screen
Owner: Procurement + legal
Deliverable: unknowns, alternatives, stop

NEXT | 1-12 MONTHS
Joint qualification
Owner: R&D + supplier
Deliverable: process window and failure data

NEXT | 1-12 MONTHS
Commercial gate
Owner: Business + finance
Deliverable: unit economics and capacity

LATER | 1-5 YEARS
Platform strategy
Owner: Executive team
Deliverable: portfolio and interface roadmap

LATER | 1-5 YEARS
Service layer
Owner: Operations + channel
Deliverable: monitoring, maintenance and recovery

GO / NO-GO GATES

GATE	OWNER	REQUIRED EVIDENCE	NO-GO CONDITION
G1 Evidence	**Quality**	Source, test conditions and reproducibility	No traceable evidence
G2 Integration	**R&D**	Interface, process window and failure analysis	Cannot meet system conditions
G3 Commercial	**Business**	Capacity, total cost, contract and alternatives	Economics or supply cannot be supported
G4 Lifecycle	**Operations**	Monitoring, maintenance, change notice and exit	No accountable operating plan

ANALYZED ARTICLES | ITEMS 01-09

Every title and URL is displayed in full. URLs wrap without shortening and remain clickable. A verified-reference label means the translated HTML did not retain its original source URL.

ID	FULL ARTICLE TITLE	FULL SOURCE / VERIFIED REFERENCE URL - CLICKABLE
A01	Longi Perovskite-Silicon Tandem Cell: 35.31% Efficiency via SAMs	https://www.pv-magazine-australia.com/2026/11/10/longi-achieves-35-31-efficiency-in-perovskite-silicon-tandem-solar-cell-based-on-self-assembled-molecules/
A02	Perovskite-Silicon Tandem Cells: 35.1% Efficiency for Space Use	https://finance.sina.com.cn/jjxw/2026-11-11/doc-iniyixya8481537.shtml
A03	Perovskite Solar Cells: 22.7% Efficiency via Ambient Slot-Die Coating	https://xenospectrum.com/perovskite-module-slot-die-high-efficiency/
A04	Perovskite Solar Cells: Grain-Boundary Charge Balance and 26.55% Efficiency	https://taiyangnews.info/technology/researchers-identify-new-cause-of-perovskite-cell-aging
A05	Perovskite Solar Cells: Taurine Application Extends Life 5x	https://www.dongascience.com/ko/news/80845
A06	Perovskite Solar Cells: Osaka University's AI-Robotic Fabrication	https://bioengineer.org/robotics-and-machine-learning-optimize-perovskite-solar-cell-fabrication-in-real-time/
A07	Tongwei Perovskite-Silicon Tandem: 2026 Production Roadmap	https://news.solarbe.com/202611/12/50031781.html
A08	Perovskite Mini-Modules: 23.9% Efficiency via Fill Factor Retention	https://www.perovskite-info.com/fill-factor-retention-helps-perovskite-mini-module-reach-certified-239
A09	Gas-FE: Solvent-free perovskite deposition at >1 µm per minute	https://www.perovskite-info.com/gas-flow-assisted-flash-evaporation-deposits-perovskite-films-over-1-m-minute

PerovskiteSolarCells — Selected Articles

Date: 2026-11-15

Articles: 9

Table of Contents

#01 Longi Perovskite-Silicon Tandem Cell: 35.31% Efficiency via SAMs

#02 Perovskite-Silicon Tandem Cells: 35.1% Efficiency for Space Use

#03 Perovskite Solar Cells: 22.7% Efficiency via Ambient Slot-Die Coating

#04 Perovskite Solar Cells: Grain-Boundary Charge Balance and 26.55% Efficiency

#05 Perovskite Solar Cells: Taurine Application Extends Life 5x

#06 Perovskite Solar Cells: Osaka University's AI-Robotic Fabrication

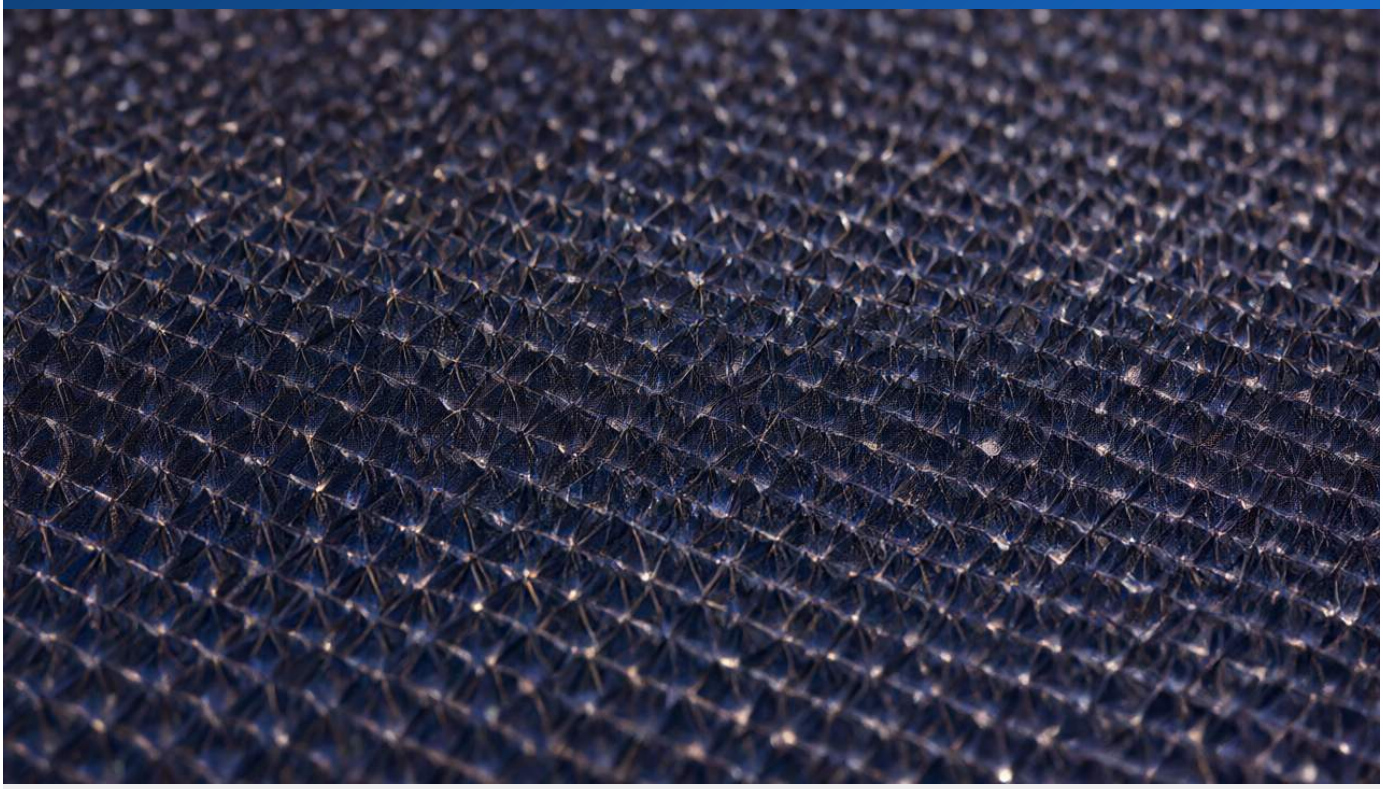
#07 Tongwei Perovskite-Silicon Tandem: 2026 Production Roadmap

#08 Perovskite Mini-Modules: 23.9% Efficiency via Fill Factor Retention

#09 Gas-FE: Solvent-free perovskite deposition at >1 μm per minute

#01 Longi Perovskite-Silicon Tandem Cell: 35.31% Efficiency via SAMs

Published November 10, 2026 pv magazine Australia Australia



OVERVIEW

Longi has achieved a power conversion efficiency of 35.31% in a perovskite-silicon tandem solar cell by utilizing engineered self-assembled molecules (SAMs). This molecular design optimizes charge transport and stability on textured surfaces, marking a significant advancement in high-efficiency photovoltaic architecture.

IN DEPTH

Key Findings

Longi has developed a two-terminal monolithic tandem solar cell reaching a champion power conversion efficiency of 35.31%. This device achieved a short-circuit current density of 20.82 mA/cm2, an open-circuit voltage of 2.007 V, and a fill factor of 84.53%. Independent certification by China's National Center of Inspection on Solar Photovoltaic Products Quality (CPVT) confirmed a reverse-scan efficiency of 35.25% and a stabilized efficiency of 35.13%.

Technical Details

The efficiency gain is attributed to the use of specially designed self-assembled molecules (SAMs) that prevent excessive molecular stacking. Researchers tested four derivatives based on the 4PACz molecule (TC0, TC1, TC2, and TC3), finding that TC2 provided the optimal balance of substrate adhesion and charge transport. Molecular simulations showed TC2 achieved 83.1% surface coverage, significantly higher than TC1 (75.0%) and TC3 (73.3%).

The TC2-based SAM modifies the indium tin oxide (ITO) work function to improve energy-level alignment for hole extraction and reduces charge recombination. Furthermore, TC2 promotes controlled perovskite crystallization, resulting in larger grains and higher crystallinity. Photoluminescence measurements for TC2 showed a quantum yield of 1.46% and a quasi-Fermi level splitting of 1.292 eV.

The device architecture consists of:

- A textured silicon heterojunction (HJT) bottom cell.
- An ITO recombination layer and a TC2-based SAM hole-selective contact.
- A perovskite absorber topped with a lithium fluoride (LiF) interlayer, C60 electron transport layer, and SnOx buffer layer.
- A transparent indium zinc oxide (IZO) electrode, silver (Ag) contact, and MgFx optical coating.

Stability and Context

Stability tests under the ISOS-L-1 protocol showed the device retained 94% of its initial efficiency after 1,500 hours of continuous operation. Under the ISOS-L-2 protocol (65 C), it retained 82% efficiency after 1,000 hours. This research, published in *Nature*, involved collaborations with Soochow University, Northwestern Polytechnical University, and Hong Kong Polytechnic University.

Significance and Outlook

This development follows a trend of molecular interface engineering. Previous milestones include a 31.71% efficient cell via chemical polishing and a 32.12% certified efficiency cell using steric-complementary interface design. Longi's latest result demonstrates that optimized molecular interfaces can simultaneously enhance efficiency, charge transport, and operational stability in tandem cells.

Source: https://www.pv-magazine-australia.com/2026/11/10/longi-achieves-35-31-efficiency-in-perovskite-silicon-tandem-solar-cell-based-on-self-assembled-molecules/

Collected: November 15, 2026 | Automated Research System (AI)

#02 Perovskite-Silicon Tandem Cells: 35.1% Efficiency for Space Use

Published November 11, 2026　新浪财经（中国科学报より転載）　China



OVERVIEW

Researchers at Soochow University have developed a perovskite-silicon tandem solar cell achieving a certified power conversion efficiency of 35.1%. This technology matches the performance of expensive multi-junction GaAs cells while reducing estimated material costs to less than 1%.

IN DEPTH

Key Findings

A research team led by Professors Zhang Xiaohong and Liu Jiang at Soochow University has achieved a certified photoelectric conversion efficiency of 35.1% with a perovskite-silicon tandem solar cell. This result matches the efficiency of traditional multi-junction Gallium Arsenide (GaAs) cells used in space applications but at an estimated cost of less than 1% of the GaAs alternative. Specifically, while GaAs cells can cost hundreds of thousands of yuan per square meter, the new cells are estimated to cost several hundred yuan per square meter.

Technical Details

The device utilizes a tandem structure where a top perovskite layer absorbs visible light and a bottom crystalline silicon layer absorbs long-wavelength infrared light, pushing the theoretical efficiency limit above 43%. To overcome the challenge of uneven coverage on the rough pyramid-textured surface of the silicon base, the team implemented a "spatial conjugate" molecular design. By introducing controllable twists within the molecules, they inhibited excessive π-π stacking, allowing for a conformal coverage rate exceeding 80% on the textured surface.

Additional milestones include:

- A certified efficiency of 34.6% on ultra-thin silicon wafers (60 micrometers thick).
- An efficiency of 29.8% on commercial silicon wafer sizes (261 square centimeters).
- Mechanical durability maintaining 97% of initial efficiency after 43,000 extreme bending cycles.

Background and Context

Traditional space-grade GaAs cells rely on expensive Metal-Organic Chemical Vapor Deposition (MOCVD) equipment and rare raw materials. In contrast, the Soochow University team uses a low-temperature solution coating method for the perovskite layer, avoiding high-temperature diffusion and expensive vacuum equipment. The project involved collaboration with LONGi, which provided and optimized the bottom crystalline silicon cells.

Significance and Outlook

The technology aligns with China's "15th Five-Year Plan" for electronic information manufacturing, which identifies space photovoltaics as a key application scenario. To achieve industrialization, the team must now verify the cells' durability against space-specific stressors, including atomic oxygen, UV radiation, and thermal cycling between -120°C and 150°C. The target for viability is maintaining over 80% efficiency after 25,000 simulated thermal cycles.

Source: https://finance.sina.com.cn/jjxw/2026-11-11/doc-iniyixya8481537.shtml

Collected: November 15, 2026 | Automated Research System (AI)

#03 Perovskite Solar Cells: 22.7% Efficiency via Ambient Slot-Die Coating

Published November 13, 2026 XenoSpectrum China



OVERVIEW

Researchers from the Chinese Academy of Sciences and Dalian Maritime University achieved a 22.70% power conversion efficiency (PCE) in a 54.80 cm² MA-free perovskite solar module using ambient slot-die coating. By utilizing two specific additives to extend the crystallization processing window to over 100 seconds, the team successfully produced uniform large-area thin films. This advancement addresses a critical bottleneck in transitioning from lab-scale spin-coating to scalable industrial manufacturing.

IN DEPTH

Key Findings

A research team led by Professor Yang Dong from the Dalian Institute of Chemical Physics (CAS) and Dalian Maritime University has developed a method to produce high-efficiency perovskite solar modules under ambient conditions. The team achieved a peak PCE of 22.70% for a module with an active area of 54.80 cm², consisting of 14 series-connected cells. For comparison, small-area cells produced using the same method reached a maximum efficiency of 26.16%.

Technical Details

To overcome the volatility and thermal instability of methylammonium (MA), the researchers used a FAxCs1-xPbI3 system. To prevent phase separation and ensure film uniformity during slot-die coating, they introduced two additives: formamidinium thiocyanate (FASCN, 2 mg/mL) and rubidium thiocyanate (RbSCN, 5 mg/mL). These additives expanded the "processing window" (the time between coating and annealing) to over 100 seconds.

- **FASCN:** Promotes nucleation and crystal growth during vacuum flash processing.
- **RbSCN:** Suppresses the non-photoactive yellow phase (δ-phase) and stabilizes the photoactive black phase (α-phase).
- **Mechanism:** DFT calculations suggest Rb+ ions reduce the activation energy for the δ-to-α phase transition from 0.68 eV to 0.64 eV.

Stability and Durability

Unencapsulated devices were tested under various conditions. In a nitrogen atmosphere at 65°C under continuous illumination (ISOS-L-3I), the additive-enhanced cells maintained 97.76% of their initial efficiency after 1,300 hours. In dark heat tests at 85°C (nitrogen), they maintained over 96% efficiency after 1,000 hours. In ambient air (30–50% humidity) without operation, they retained over 97% efficiency after 1,600 hours.

Significance and Outlook

The research demonstrates that increasing the tolerance of the crystallization process reduces film variance; efficiency deviations on 10 cm x 10 cm substrates dropped to less than ±0.48 compared to ±1.16 for additive-free films. Future milestones include third-party certification of the 22.70% efficiency, long-term lifetime evaluations of encapsulated modules in real-world environments, and validation on continuous roll-to-roll production lines.

Source: https://xenospectrum.com/perovskite-module-slot-die-high-efficiency/

Collected: November 15, 2026 | Automated Research System (AI)

#04 Perovskite Solar Cells: Grain-Boundary Charge Balance and 26.55% Efficiency

Published November 10, 2026 TaiyangNews



OVERVIEW

Researchers from Hong Kong Polytechnic University and Zhejiang University have identified that uneven charge losses between neighboring crystal grains accelerate light-induced degradation in perovskite solar cells. By applying a chemical treatment to homogenize these losses, the team achieved a power conversion efficiency of 26.55% and maintained over 90% performance after 2,200 hours of continuous illumination.

IN DEPTH

Key Findings

A joint study by Hong Kong Polytechnic University (PolyU) and Zhejiang University has revealed a new cause of light-induced degradation (LID) in perovskite solar cells: uneven charge losses between neighboring crystal grains. The researchers developed a grain-boundary treatment that balances these losses, resulting in cells with 26.55% efficiency. These treated cells demonstrated high stability, retaining more than 90% of their initial performance after over 2,200 hours of continuous illumination under 1 sun.

Technical Details

The study, published in the journal *Watt* under the title "Stabilizing high-efficiency perovskite solar cells by homogenizing inter-grain recombination," focused on the interactions between crystal grains with different surface orientations, specifically (100) and (111). The researchers found that defects—primarily missing formamidinium (FA) ions—were concentrated on the (111) side. These vacancies caused the accumulation of positively charged carriers (holes) near grain boundaries, accelerating degradation in (111) grains despite their inherent resistance to light-induced aging.

To mitigate this, the team employed 3 fluorophenylethylammonium bromide (m-F-PEABr). This chemical compound resides at the grain boundaries rather than entering the crystals. Its positively charged molecular groups occupy the sites left vacant by missing FA ions, thereby homogenizing charge losses between neighboring grains.

Background and Significance

While previous efforts to improve perovskite stability focused on reducing the total number of defects, PolyU Assistant Professor Guang Yang notes that this approach alone may be insufficient. The findings indicate that the relative balance of charge losses between grains is a critical factor in overall cell durability.

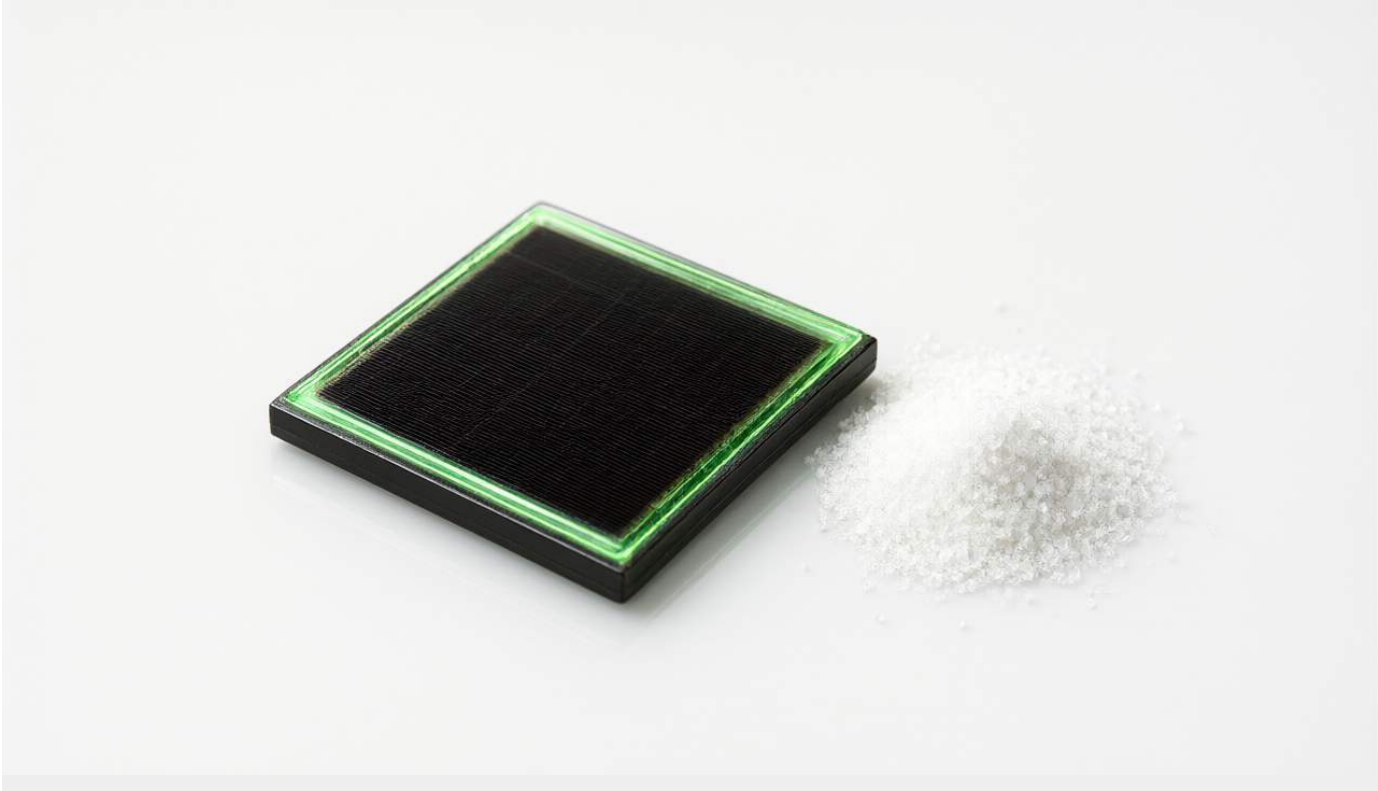
While these results show improved resistance to LID under laboratory conditions, the researchers state that further testing under outdoor operating conditions is required to determine the treatment's viability for long-term solar module applications.

Source: https://taiyangnews.info/technology/researchers-identify-new-cause-of-perovskite-cell-aging

Collected: November 15, 2026 | Automated Research System (AI)

#05 Perovskite Solar Cells: Taurine Application Extends Life 5x

Published November 12, 2026 동아사이언스 South Korea



OVERVIEW

Researchers have extended the lifespan of perovskite solar cells by five times by applying taurine, an antioxidant, to the interface between the metal oxide and perovskite layers. This method suppresses the degradation caused by superoxide radicals, maintaining over 95% of initial efficiency after 500 hours of continuous light exposure.

IN DEPTH

Key Findings

A joint research team from the Daegu Gyeongbuk Institute of Science and Technology (DGIST) and the Korea Institute of Science and Technology (KIST) Chonbuk Branch has successfully increased the operational stability of perovskite solar cells. The team identified the mechanism by which these cells self-destruct and developed a design to block this process using taurine. The results were published as a cover story in the journal Advanced Energy Materials on October 21.

Technical Details

The research focuses on the interface where the metal oxide layer meets the perovskite layer. During operation, the metal oxide layer generates superoxides ($O_2^{\cdot-}$), a type of active oxygen that damages the crystal structure of the perovskite, leading to decomposition. By applying a thin antioxidant layer of taurine to this boundary, the team achieved the following:

- **Degradation Suppression:** Taurine continuously removes superoxides, inhibiting the decomposition of the perovskite structure.
- **Structural Repair:** Taurine acts as a "chemical bridge," filling microscopic defects at the interface to facilitate smoother electron movement and improve overall efficiency.
- **Stability Metrics:** In operational stability tests, the T80 (the time taken for efficiency to drop to 80% of the initial value) increased from 23.6 hours to 130 hours, a more than five-fold improvement.
- **Long-term Performance:** Cells treated with taurine maintained over 95% of their initial efficiency after more than 500 hours of continuous light exposure.

Background and Significance

Perovskite solar cells are considered high-efficiency alternatives to traditional silicon cells. However, their susceptibility to decomposition when exposed to light and heat has been a primary barrier to commercialization. Professor Jong-min Choi of DGIST stated that clarifying the role of superoxides in the decomposition process and solving it via antioxidant interface design provides a core foundational technology to accelerate the commercialization of perovskite solar cells.

Source: https://www.dongascience.com/ko/news/80845

Collected: November 15, 2026 | Automated Research System (AI)

#06 Perovskite Solar Cells: Osaka University's AI-Robotic Fabrication

Published November 12, 2026 BIOENGINEER.ORG USA



OVERVIEW

Researchers at the University of Osaka have developed an automated robotic platform integrated with machine learning to optimize perovskite solar cell fabrication in real time. The system achieved a power conversion efficiency of 24.4 percent by precisely controlling the crystallization process. This approach replaces conventional trial-and-error methods with a systematic protocol for improving thin-film quality.

IN DEPTH

Key Findings

The University of Osaka research team has successfully fabricated a lead-based perovskite solar cell with a power conversion efficiency of 24.4 percent. This result was achieved by utilizing an automated robotic platform and machine learning algorithms to refine the antisolvent coating process and determine the optimal range for droplet behavior.

Technical Details

The platform integrates film deposition with high-resolution optical imaging and environmental measurements to track the transition from a liquid precursor solution to a solid crystalline film. To capture rapid physical changes, the system was designed with the following capabilities:

- Subsecond interval capture of film color variations.
- Millisecond-level resolution of the motion and impact of antisolvent droplets.
- Real-time tracking of the influence of humidity, temperature, and processing conditions on liquid crystallization.

Machine learning algorithms were employed to parse the large volumes of diagnostic data generated by the robotic system. This allowed the researchers to identify complex relationships between multifaceted processing variables and the resulting material outcomes that are typically undetectable via manual fabrication.

Background & Context

Perovskite solar cells generate electricity via a thin light-absorbing layer. A persistent challenge in manufacturing is that minor fluctuations in environmental conditions during the drying and crystallization phase can substantially alter electrical efficiency and film quality. Lead author Ryosuke Kado noted that the project sought to move beyond conventional trial-and-error by directly connecting real-time physical shifts to the final quality of the film.

Significance & Outlook

By unifying automated experimentation, real-time measurements, and statistical analysis, this platform provides a systematic protocol for uncovering previously unknown relationships between fabrication variables and thin-film quality. Senior author Akinori Saeki highlighted that automated instrumentation collects significantly richer information than manual methods. The researchers suggest this approach could catalyze photovoltaic research and support the development of more practical perovskite solar cells.

Source: https://bioengineer.org/robotics-and-machine-learning-optimize-perovskite-solar-cell-fabrication-in-real-time/

Collected: November 15, 2026 | Automated Research System (AI)

#07 Tongwei Perovskite-Silicon Tandem: 2026 Production Roadmap

Published November 12, 2026 索比光伏网 China



OVERVIEW

Tongwei has transitioned perovskite-silicon tandem cells from laboratory records to megawatt-scale validation, achieving a 210 half-cut cell efficiency of 33.09%. By utilizing a "vapor deposition + solution two-step" process and a 5MW automated line, the company has reduced material costs by 60%.

IN DEPTH

Key Findings

Tongwei has achieved a conversion efficiency of 33.09% for 210 half-cut full-area perovskite-heterojunction (HJT) tandem cells. As of October 2026, the company's 5MW fully automated tandem experimental line maintains a stable average daily efficiency exceeding 30%, with 210-66 model tandem modules reaching a power output of 813W.

Technical Details

To ensure commercial manufacturability, Tongwei employs a "vapor deposition + solution two-step" route compatible with existing HJT production lines. This method isolates film formation, nucleation, and crystallization, resulting in perovskite films on textured silicon surfaces with non-uniformity of less than 1% and no edge effects.

Cost and reliability optimizations include:

- **Cost Reduction:** Material costs on the experimental line decreased by 60% through the use of domestic material substitution and recycling systems.
- **Metallization:** The application of 0BB and silver-coated copper ultra-low temperature metallization has reduced the consumption of pastes and adhesive films.
- **Stability:** To combat UV degradation and halide migration, Tongwei implemented dense passivation layers, consistent crystallization orientation to relieve lattice stress, and high-dispersion SAM for UV resistance.
- **Validation:** Devices have surpassed 1,000 hours of T90 in 85°C full-spectrum MPPT testing, with outdoor validation ongoing in Jiuquan, Gansu, and other climatic zones.

Background and Context

These results were presented by Dr. Hu Yuchao at the 7th China New Materials Industry Development Conference in Nanjing. The development follows the completion of a 5MW automated line in September 2025, establishing a full R&D chain from laboratory to pilot line and outdoor verification.

Significance and Outlook

Tongwei is shifting its priority from absolute efficiency to mass-production feasibility. Future plans include the construction of an AI high-throughput experimental platform to accelerate the iteration of cation formulas and interface materials. The company intends to scale toward hundred-megawatt capacity and customize modules for diverse applications, including vehicle-mounted curved photovoltaics, space photovoltaics, and distributed power stations.

Source: https://news.solarbe.com/202611/12/50031781.html

Collected: November 15, 2026 | Automated Research System (AI)

#08 Perovskite Mini-Modules: 23.9% Efficiency via Fill Factor Retention

Published November 06, 2026 Perovskite-Info



OVERVIEW

Researchers have achieved a certified steady-state efficiency of 23.9% for a perovskite mini-module with a 19.48 cm² aperture area. By utilizing a cryo-controlled processing step to preserve the fill factor, the team addressed efficiency losses typically associated with scaling from lab-scale devices to modules.

IN DEPTH

Key Findings

A research collaboration involving Microquanta Semiconductor, Zhejiang University, China Three Gorges Renewable, the Australian Centre for Advanced Photovoltaics, and the Zhejiang Provincial Key Laboratory of Optoelectronic Functional Materials and Devices has developed a perovskite mini-module reaching a certified steady-state efficiency of 23.9%. The device, featuring an aperture area of 19.48 cm², achieved a fill factor of 83.3%.

Technical Details

The team conducted an analysis to determine why perovskite solar cells lose efficiency during the transition from lab-scale devices to larger modules. Their findings identified the fill factor as a primary contributor to this efficiency drop. The researchers further categorized the fill factor deficit into three specific contributions:

- Voltage-related contributions
- Diode-non-ideality
- Transport-related contributions

To mitigate these losses, the team implemented a cryo-controlled processing step designed to regulate the evolution of an intermediate phase during crystallization. According to the researchers, the resulting improvement is mainly attributed to reduced diode non-ideality, with other contributions playing a smaller role. The team noted that the advantages of this processing approach increase as the device size grows.

Background and Context

The study focuses on the "scale-up gap," where perovskite technologies often see a decline in performance when moving from small-scale laboratory cells to larger modules. By isolating the fill factor as the critical variable, the researchers were able to target the crystallization process to maintain performance across a larger surface area.

Significance and Outlook

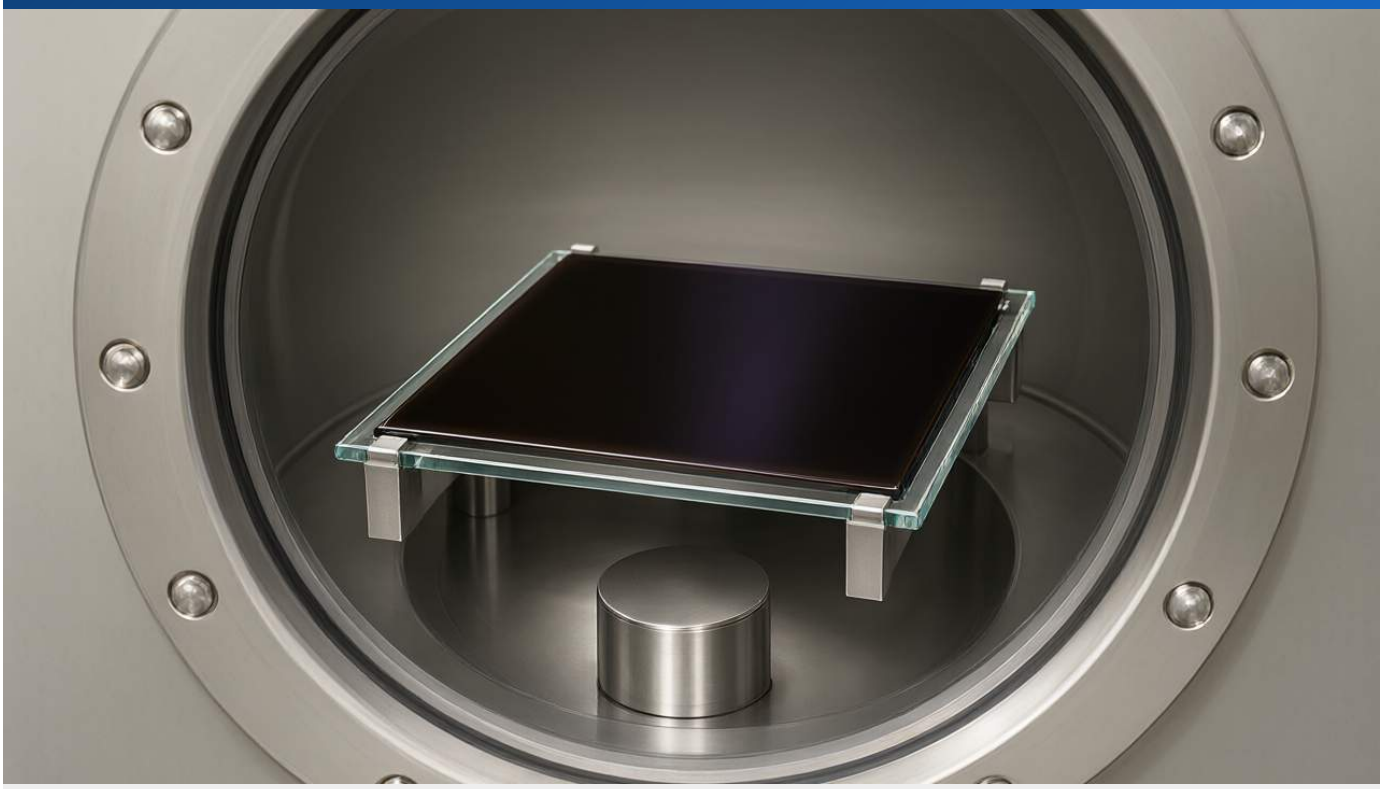
Beyond initial efficiency, the researchers indicate that the same fill factor limitations that affect scale-up also govern performance decay during operation. This suggests a direct link between efficiency retention during the scaling process and the long-term stability of the solar cells, providing a potential pathway for improving the durability of large-area perovskite modules.

Source: https://www.perovskite-info.com/fill-factor-retention-helps-perovskite-mini-module-reach-certified-239

Collected: November 15, 2026 | Automated Research System (AI)

#09 Gas-FE: Solvent-free perovskite deposition at >1 µm per minute

Published November 13, 2026 Perovskite-Info スペイン



OVERVIEW

Researchers from ICMol and Oxford PV have developed gas flow assisted flash evaporation (Gas-FE), a solvent-free vacuum technique capable of depositing perovskite films at rates exceeding 1 µm per minute. By utilizing a pre-formulated powder aerosol, the method simplifies composition control and significantly reduces deposition time compared to conventional co-evaporation.

IN DEPTH

Key Findings

The Gas-FE method achieved a measured growth rate of approximately 18.6 nm/s, or roughly 1.1 µm per minute. Using methylammonium lead iodide ($MAPbI_3$) with 10 mol% methylammonium chloride and 8 mol% lithium TFSI, the team deposited films ranging from 100 to 1,100 nm in thickness by adjusting powder injection times between 7 and 60 seconds. On a 10 × 10 cm² substrate, the I:Pb ratio varied by less than 5% and film thickness by 4%, with run-to-run variation between 6% and 8%.

Technical Details

Unlike conventional co-evaporation, which requires separate sources for each component, Gas-FE uses a single pre-formulated, ball-milled perovskite powder. The process operates as follows:

- An auger screw feeds the powder into a nitrogen gas flow to create an aerosol.
- The aerosol passes through a vaporizer heated to 500 °C.
- Vapor is delivered via a heated showerhead onto a temperature-controlled substrate holder.
- The system operates at a roughing-pump vacuum of approximately 10 mbar.

The researchers demonstrated the ability to transfer components with widely different volatilities, including lead iodide, formamidinium bromide, methylammonium iodide, lithium TFSI, benzylphosphonic acid, amantadine hydrochloride, and guanidinium iodide. X-ray diffraction also confirmed film formation from mixed-cation and mixed-halide FA/Cs powders.

Background & Context

Traditional co-evaporation becomes increasingly complex as formulations include more trace additives, often requiring hours of deposition time. Previous flash-evaporation methods were limited by the throughput of feeding powder into a heated crucible. Gas-FE addresses these bottlenecks and shortens the turnaround time between batches compared to high-vacuum deposition.

Significance & Outlook

As a proof-of-concept, 250 nm films were integrated into a fully vacuum-deposited p-i-n solar cell (glass/FTO/MeO-2PACz/perovskite/C60/SnO_2/Cu). The best 0.05 cm² device reached a power conversion efficiency of 9.6%, with an open-circuit voltage of 0.91 V, a short-circuit current density of 16.8 mA/cm², and a fill factor of 63.3%. The team indicates that future improvements should target trap density and interfaces to address the current spread in voltage and fill factor.

Source: https://www.perovskite-info.com/gas-flow-assisted-flash-evaporation-deposits-perovskite-films-over-1-m-minute

Collected: November 15, 2026 | Automated Research System (AI)