TROY TECHNICAL

PEROVSKITE SOLAR CELLS

WEEKLY REPORT

November 14 - November 20, 2026 | Issue 2026-W46

Bankable module performance, durability, manufacturing yield and market entry

11	10
ANALYZED ARTICLES	PRIORITY THEMES

Issued 2026-11-20 | English edition | fixed approved cover artwork



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

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

SIGNAL 01 | PRECURSORS

Perovskite Stability: Nanodiamonds and Mechanical Heterogeneity

Researchers at Zhejiang University have achieved a certified steady-state power conversion efficiency of 27.04% by incorporating nanodiamonds into perovskite thin films.

SIGNAL 02 | CELL STACK

Perovskite Tandem Cells: Efficiency Gains vs Lead Sustainability

Chinese firms are accelerating tandem cell efficiency, with records reaching 35.5%, but lead-based toxicity remains a critical barrier.

SIGNAL 03 | MODULE PROCESS

MicroQuanta: 23.9% Efficiency Record for 19.48 cm2 Perovskite Module

MicroQuanta Semiconductor and Zhejiang University have achieved a world-record certified steady-state efficiency of 23.9% for a 19.48 cm2 perovskite mini-module.

SIGNAL 04 | QUALIFICATION

JinkoSolar: Perovskite-Silicon Tandem Cell Hits 35.24% Efficiency

JinkoSolar has achieved a power conversion efficiency of 35.24% for a perovskite-silicon tandem solar cell, certified by the Chinese Academy of Sciences.

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

27.04%
A08

SOURCE-BOUND CONDITION
Researchers at Zhejiang University have achieved a certified steady-state power conversion efficiency of 27.04% by incorporating nanodiamonds into perovskite thin films.

35.5%
A10

SOURCE-BOUND CONDITION
Chinese firms are accelerating tandem cell efficiency, with records reaching 35.5%, but lead-based toxicity remains a critical barrier.

23.9%
A02

SOURCE-BOUND CONDITION
MicroQuanta Semiconductor and Zhejiang University have achieved a world-record certified steady-state efficiency of 23.9% for a 19.48 cm2 perovskite mini-module.

35.24%
A03

SOURCE-BOUND CONDITION
JinkoSolar has achieved a power conversion efficiency of 35.24% for a perovskite-silicon tandem solar cell, certified by the Chinese Academy of Sciences.

525 W
A07

SOURCE-BOUND CONDITION
Sirius PV has introduced the HybridTandem residential solar module, achieving 525 W DC using Caelux's Energy Producing Glass.

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

Researchers at Zhejiang University have achieved a certified steady-state power conversion efficiency of 27.04% by.

2

Cell stack

P02/P07

Chinese firms are accelerating tandem cell efficiency, with records reaching 35.5%, but lead-based toxicity remains a.

3

Module proce ss

P03/P08

MicroQuanta Semiconductor and Zhejiang University have achieved a world-record certified steady-state efficiency of 23.9% for.

4

Qualification

P04/P09

JinkoSolar has achieved a power conversion efficiency of 35.24% for a perovskite-silicon tandem solar cell, certified by the.

5

Deployment & recycling

P05/P10

Sirius PV has introduced the HybridTandem residential solar module, achieving 525 W DC using Caelux's Energy Producing Glass.

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	Perovskite Stability: Nanodiamonds and Mechanical Heterogeneity System / adoption | cue: operational
P02	Perovskite Tandem Cells: Efficiency Gains vs Lead Sustainability Business / rules | cue: standardized
P03	MicroQuanta: 23.9% Efficiency Record for 19.48 cm2 Perovskite Module Tech / process | cue: no system/business cue
P04	JinkoSolar: Perovskite-Silicon Tandem Cell Hits 35.24% Efficiency Tech / process | cue: no system/business cue
P05	Sirius PV: 525 W Perovskite Tandem Modules and 2027 Roadmap System / adoption | cue: partnered
P06	One-Dimensional Spiral Perovskites: Circular Polarization Sensing Tech / process | cue: no system/business cue
P07	Perovskite Solar Cells: Band-Edge-Extended Heterointerfaces for 27.96% PCE Tech / process | cue: no system/business cue
P08	n-i-p All-Perovskite Tandem Solar Cells: 25.3% Efficiency Specs Tech / process | cue: no system/business cue
P09	Perovskite-Silicon Tandems: Vacuum Deposition and 30.3% Efficiency Tech / process | cue: no system/business cue
P10	Perovskite Solar Cells: Xi'an Jiaotong University's 27.96% Efficiency Interface Solution 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 Perovskite Stability: Nanodiamonds and Mechanical Heterogeneity

A08 | Precursors | Pilot

2026-11-20

FACT

Researchers at Zhejiang University have achieved a certified steady-state power conversion efficiency of 27.04% by incorporating nanodiamonds into perovskite thin films. This approach addresses stability issues by mitigating mechanical heterogeneity and stress concentration at grain boundaries, significantly extending operational lifespan.

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 21/25 | MATURITY 2/5 | DECISION LOCUS: SYSTEM / ADOPTION

P02 Perovskite Tandem Cells: Efficiency Gains vs Lead Sustainability

A10 | Cell stack | Research

2026-11-19

FACT

Chinese firms are accelerating tandem cell efficiency, with records reaching 35.5%, but lead-based toxicity remains a critical barrier. While recycling methods and lead-free alternatives are being explored, the lack of standardized green regulations threatens mass-market viability.

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 21/25 | MATURITY 1/5 | DECISION LOCUS: BUSINESS / RULES

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

P03 MicroQuanta: 23.9% Efficiency Record for 19.48 cm2 Perovskite Module

A02 | Module process | Research

2026-11-19

FACT

MicroQuanta Semiconductor and Zhejiang University have achieved a world-record certified steady-state efficiency of 23.9% for a 19.48 cm2 perovskite mini-module. The team mitigated efficiency losses during scaling by implementing a cooling step to optimize the fill factor. This advancement addresses a critical bottleneck in transitioning perovskite solar technology from laboratory cells to practical, large-area 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 P03.

UNKNOWN

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

EDITORIAL SCORE 20/25 | MATURITY 1/5 | DECISION LOCUS: TECH / PROCESS

P04 JinkoSolar: Perovskite-Silicon Tandem Cell Hits 35.24% Efficiency

A03 | Qualification | Research

2026-11-20

FACT

JinkoSolar has achieved a power conversion efficiency of 35.24% for a perovskite-silicon tandem solar cell, certified by the Chinese Academy of Sciences. This result marks an improvement over the company's previous 34.82% efficiency and places it among the top performers in the tandem cell sector.

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 1/5 | DECISION LOCUS: TECH / PROCESS

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

P05 Sirius PV: 525 W Perovskite Tandem Modules and 2027 Roadmap

A07 | Deployment & recycling | Research

2026-11-19

FACT

Sirius PV has introduced the HybridTandem residential solar module, achieving 525 W DC using Caelux's Energy Producing Glass. The company also partnered with IronRidge to integrate EPIC Aire compatible frames to reduce residential installation time by up to 30%.

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 20/25 | MATURITY 1/5 | DECISION LOCUS: SYSTEM / ADOPTION

P06 One-Dimensional Spiral Perovskites: Circular Polarization Sensing

A06 | Precursors | Joint evaluation

2026-11-19

FACT

A research group from Waseda University, the National Institute of Advanced Industrial Science and Technology, and Tokyo University of Science has developed a semiconductor thin film capable of identifying the rotation direction of light and generating photocurrent without external voltage. The material achieves a circular polarization discrimination ratio of approximately 105 and a photovoltage of about 2V.

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: TECH / PROCESS

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

P07 Perovskite Solar Cells: Band-Edge-Extended Heterointerfaces for 27.96% PCE

A01 | Cell stack | Pilot

2026-11-18

FACT

Researchers have developed electronically coupled heterointerfaces using fully conjugated formamidinium modulators to overcome charge extraction bottlenecks in perovskite solar cells. This approach achieved a certified power-conversion efficiency (PCE) of 27.96% and enabled a monolithic perovskite-silicon tandem cell with a certified stabilized power output (SPO) of 34.71%.

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: TECH / PROCESS

P08 n-i-p All-Perovskite Tandem Solar Cells: 25.3% Efficiency Specs

A04 | Module process | Pilot

2026-11-20

FACT

Researchers have achieved a record 25.3% efficiency for n-i-p double-junction all-perovskite tandem solar cells by engineering the interconnection layer. This architecture overcomes material constraints and thermal stability issues, enabling a four-terminal triple-junction device to reach 28% efficiency.

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 2/5 | DECISION LOCUS: TECH / PROCESS

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

P09 Perovskite-Silicon Tandems: Vacuum Deposition and 30.3% Efficiency

A11 | Qualification | Pilot

2026-11-17

FACT

Researchers have developed a vacuum evaporation process using a cesium chloride primer to achieve uniform perovskite growth on textured silicon surfaces. This method has demonstrated a solar cell efficiency of 30.3%, overcoming the limitations of traditional solution-based deposition.

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

P10 Perovskite Solar Cells: Xi'an Jiaotong University's 27.96% Efficiency Interface Solution

A09 | Deployment & recycling | Pilot

2026-11-20

FACT

Researchers at Xi'an Jiaotong University have developed a new interface control technology using heteroatom-containing fully conjugated formamidinium molecules to simultaneously improve efficiency and stability. The method achieved a 27.96% photoelectric conversion efficiency in single-junction cells and 34.74% in perovskite-silicon tandem cells.

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 P10.

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 01-11

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	Perovskite Solar Cells: Band-Edge-Extended Heterointerfaces for 27.96% PCE	https://doi.org/10.1038/s41586-026-11427-1
A02	MicroQuanta: 23.9% Efficiency Record for 19.48 cm2 Perovskite Module	https://www.pv-magazine.com/2026/11/19/microquanta-achieves-world-record-efficiency-of-23-9-for-19-48-cm%c2%b2-perovskite-solar-module/
A03	JinkoSolar: Perovskite-Silicon Tandem Cell Hits 35.24% Efficiency	https://www.pv-magazine.com/2026/11/20/jinkosolar-claims-35-24-efficiency-for-perovskite-silicon-tandem-solar-cell/
A04	n-i-p All-Perovskite Tandem Solar Cells: 25.3% Efficiency Specs	https://www.nature.com/articles/s41467-026-79553-y
A05	Benzeneseleninic Acid: Boosting Perovskite Solar Cell Efficiency to 26.56%	https://bioengineer.org/benzeneseleninic-acid-interfacial-strategy-boosts-perovskite-solar-cell-efficiency-to-26-56-percent/
A06	One-Dimensional Spiral Perovskites: Circular Polarization Sensing	https://www.nikkei.com/article/DGXZRSP715521_Z11C26A1000000/
A07	Sirius PV: 525 W Perovskite Tandem Modules and 2027 Roadmap	https://www.pv-magazine.com/2026/11/19/sirius-pv-unveils-525-w-perovskite-tandem-residential-modules-debuts-ironridge-partnership/
A08	Perovskite Stability: Nanodiamonds and Mechanical Heterogeneity	https://news.qq.com/rain/a/20261120A0CQA700
A09	Perovskite Solar Cells: Xi'an Jiaotong University's 27.96% Efficiency Interface Solution	https://feng.ifeng.com/c/8yCOmWq7zSH
A10	Perovskite Tandem Cells: Efficiency Gains vs Lead Sustainability	https://news.cgtn.com/news/2026-11-19/Beyond-efficiency-Perovskite-s-green-ledger-remains-unbalanced-1ScPEMB6kFy/p.html
A11	Perovskite-Silicon Tandems: Vacuum Deposition and 30.3% Efficiency	https://www.weltderphysik.de/gebiet/technik/energie/solarenergie/photovoltaik/gleichmaessiges-wachstum-von-perowskit-auf-silizium/

PerovskiteSolarCells — Selected Articles

Date: 2026-11-21

Articles: 11

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#04 n–i–p All-Perovskite Tandem Solar Cells: 25.3% Efficiency Specs

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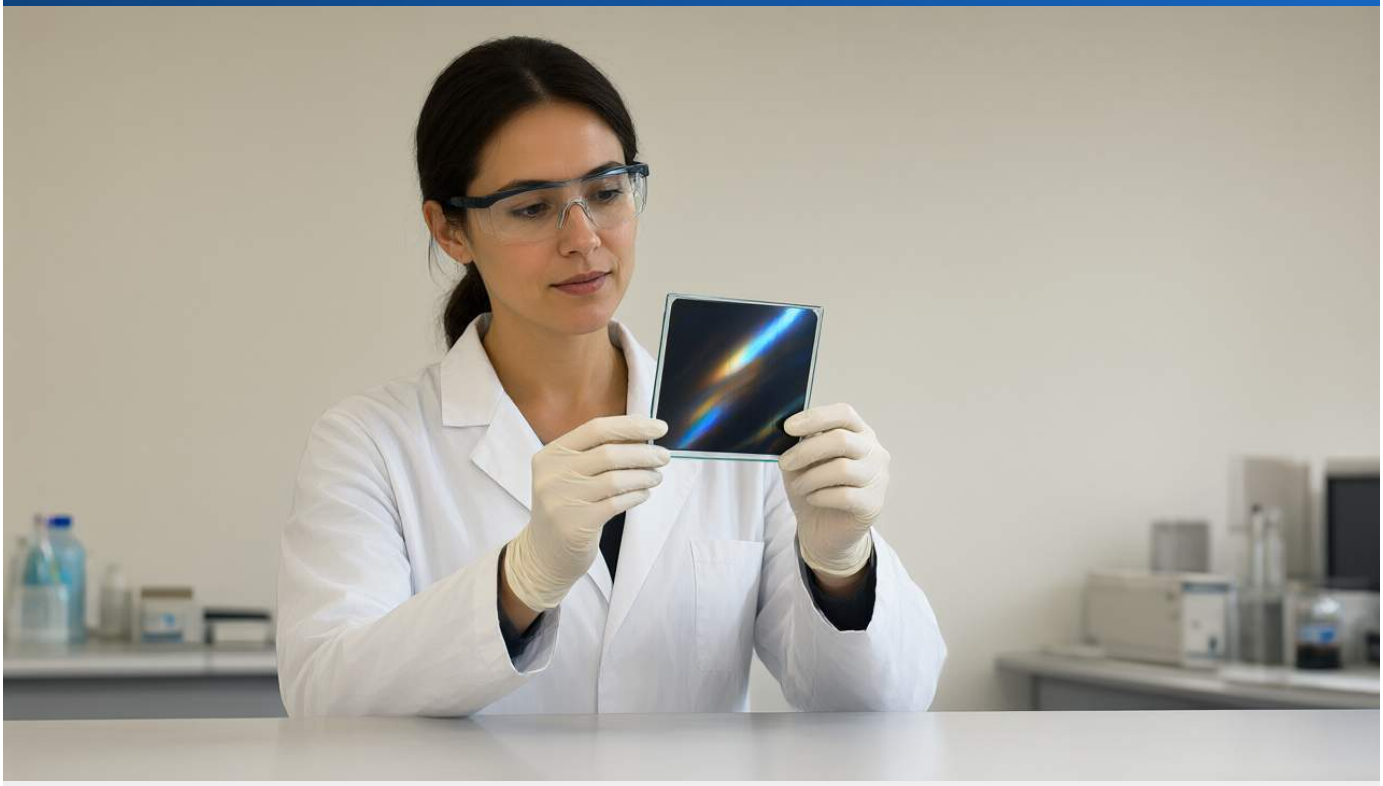
#01 Perovskite Solar Cells: Band-Edge-Extended Heterointerfaces for 27.96% PCE

Published November 18, 2026 Nature China



OVERVIEW

Researchers have developed electronically coupled heterointerfaces using fully conjugated formamidinium modulators to overcome charge extraction bottlenecks in perovskite solar cells. This approach achieved a certified power-conversion efficiency (PCE) of 27.96% and enabled a monolithic perovskite–silicon tandem cell with a certified stabilized power output (SPO) of 34.71%.

IN DEPTH

Key Findings

The study reports a certified power-conversion efficiency (PCE) of 27.96% and a stabilized power output (SPO) of 27.84% for inverted perovskite solar cells (PSCs). When applied to monolithic perovskite–silicon tandems, this strategy resulted in a certified SPO of 34.71%. Furthermore, the inverted PSC devices demonstrated high stability, retaining over 95% of their initial efficiency after 2000 h of continuous maximum-power-point tracking under 1-sun irradiation (ISOS-L).

Technical Details

To address efficiency limits caused by charge extraction and recombination at the interface between the perovskite absorber and the electron-transport layer (ETL), the researchers introduced a family of heteroatom-containing, fully conjugated formamidinium interfacial modulators. These modulators create band-edge-extending conjugated heterointerfaces that provide delocalized electron connectivity at the perovskite/ETL interface. This mechanism specifically suppresses interfacial non-radiative recombination and overcomes the inefficiency of interfacial electron transfer.

Background and Context

While perovskite solar cells are rapidly approaching the efficiencies of crystalline-silicon cells, further gains have been hindered by interfacial losses. Conventional ammonium-based interfacial modifiers are often weakly electronically coupled to the perovskite surface, which can introduce barriers that impede electron extraction. The development of electronically coupled heterointerfaces aims to resolve the traditional trade-off between interfacial passivation and efficient charge extraction.

Significance and Outlook

The establishment of band-edge extension as a broadly applicable approach allows for the simultaneous optimization of passivation and charge transport. By eliminating the bottleneck of inefficient electron transfer, this method provides a pathway to higher efficiencies in both single-junction inverted PSCs and monolithic tandem configurations, enhancing the overall viability of perovskite-based photovoltaics.

Source: https://doi.org/10.1038/s41586-026-11427-1

Collected: November 21, 2026 | Automated Research System (AI)

#02 MicroQuanta: 23.9% Efficiency Record for 19.48 cm² Perovskite Module

Published November 19, 2026 pv magazine International China



OVERVIEW

MicroQuanta Semiconductor and Zhejiang University have achieved a world-record certified steady-state efficiency of 23.9% for a 19.48 cm² perovskite mini-module. The team mitigated efficiency losses during scaling by implementing a cooling step to optimize the fill factor. This advancement addresses a critical bottleneck in transitioning perovskite solar technology from laboratory cells to practical, large-area modules.

IN DEPTH

Key Findings

A research team led by MicroQuanta Semiconductor has set a new world record with a certified steady-state efficiency of 23.9% for a 19.48 cm² perovskite mini-module. The result, certified by the National PV Industry Measurement and Testing Center (NPVM) of China's Fujian Metrology Institute, also achieved a fill factor of 83.3% and a geometric fill factor of 97%.

Technical Details

Using Shapley value analysis, researchers identified the fill factor as the primary contributor to efficiency drops when scaling from small cells to modules. To mitigate this, the team implemented a specific thermal management process during fabrication:

- Perovskite precursor was spin-coated onto ITO-coated glass with two hole-transport layers (HTLs).
- The wet film was cooled to 0-10 °C for 15 seconds immediately after coating.
- The film was transferred to a vacuum chamber within five seconds for a two-minute vacuum-flash, followed by annealing at 110 °C for 30 minutes.

This cooling process slowed the conversion of the intermediate phase into perovskite, resulting in larger and more uniform grains. The final 19.48 cm² mini-module consists of eight subcells connected in series via laser scribing. The device architecture utilizes a FA_{0}.<0xE2><0x82><0x89>$_{5}Cs_{0.05}PbI_{3}$ absorber, a 3PATAT-C3 self-assembled monolayer, an $EDAI_{2}$ surface passivation layer, a C_{60} electron transport layer, a BCP buffer layer, and a silver (Ag) electrode.

Background and Context

The study, published in *Nature Communications*, involved collaborations between MicroQuanta Semiconductor, Zhejiang University, China Three Gorges Renewable, the Zhejiang Provincial Key Laboratory of Optoelectronic Functional Materials and Devices, and the Australian Centre for Advanced Photovoltaics.

Significance and Outlook

The cooling step not only improved initial efficiency but also enhanced stability; efficiency loss due to declining fill factor was less than one-third as large compared to control modules during aging tests. MicroQuanta is further expanding its capacity with a gigawatt-scale production line in Quzhou, targeting 2.88 m² modules with 20% efficiency and a 25-year lifespan. Additionally, the company has introduced the MQ-α² series perovskite-silicon tandem modules for BIPV, reporting 26% efficiency and power outputs between 65 W and 165 W.

Source: https://www.pv-magazine.com/2026/11/19/microquanta-achieves-world-record-efficiency-of-23-9-for-19-48-cm%c2%b2-perovskite-solar-module/

Collected: November 21, 2026 | Automated Research System (AI)

#03 JinkoSolar: Perovskite-Silicon Tandem Cell Hits 35.24% Efficiency

Published November 20, 2026 pv magazine International Germany



OVERVIEW

JinkoSolar has achieved a power conversion efficiency of 35.24% for a perovskite-silicon tandem solar cell, certified by the Chinese Academy of Sciences. This result marks an improvement over the company's previous 34.82% efficiency and places it among the top performers in the tandem cell sector.

IN DEPTH

Key Findings

JinkoSolar has announced a power conversion efficiency of 35.24% for its perovskite-silicon tandem solar cell. The result was certified by the Shanghai Institute of Microsystem and Information Technology of the Chinese Academy of Sciences (CAS). This achievement represents an increase from the company's previous efficiency record of 34.82% using the same cell configuration.

Technical Details

The company stated that the efficiency breakthrough was achieved over a five-month period. JinkoSolar attributed the improvement to several core technological innovations, including:

- Selective passivation technology for textured silicon surfaces in N-type TOPCon.
- A perovskite multi-component crystallization synchronization control strategy.
- Nanoscale interface passivation materials.
- Light-management enhancement technologies.

Further technical specifications regarding the cell architecture or the specific nature of the efficiency gains were not disclosed.

Background & Context

The current world record for perovskite-silicon tandem solar cell efficiency is held by Longi, which reached 35.5% in July 2026. Longi's record, certified by the European Solar Test Installation (ESTI), utilized a two-terminal tandem cell and surpassed its own previous record of 34.85% from April 2025. Additionally, Longi has reported an efficiency of 35.31% using specially designed self-assembled molecules and a 34.3% efficiency for a large-area tandem cell measuring 261 cm^2.

Other industry developments include Trinasolar, which achieved 32.6% efficiency in January 2026 for a large-area tandem cell developed with Huairou Laboratory. That result was certified by Germany’s Fraunhofer Institute for Solar Energy Systems (Fraunhofer ISE).

Significance & Outlook

The rapid succession of efficiency gains among Chinese manufacturers—including JinkoSolar, Longi, and Trinasolar—highlights a competitive push toward the theoretical limits of tandem cell technology. The transition from standard silicon to perovskite-silicon configurations is driving a trend of incremental breakthroughs in passivation and crystallization control to maximize power conversion.

Source: https://www.pv-magazine.com/2026/11/20/jinkosolar-claims-35-24-efficiency-for-perovskite-silicon-tandem-solar-cell/

Collected: November 21, 2026 | Automated Research System (AI)

#04 n–i–p All-Perovskite Tandem Solar Cells: 25.3% Efficiency Specs

Published November 20, 2026 Nature Communications South Korea



OVERVIEW

Researchers have achieved a record 25.3% efficiency for n–i–p double-junction all-perovskite tandem solar cells by engineering the interconnection layer. This architecture overcomes material constraints and thermal stability issues, enabling a four-terminal triple-junction device to reach 28% efficiency.

IN DEPTH

Key Findings

The study reports the first n–i–p double-junction perovskite device to exceed 25% efficiency, specifically achieving 25.3% for 0.096 cm² devices and 24.7% for 1.045 cm² devices, with a stabilized power output of 24.4%. Furthermore, integrating this n–i–p double-junction device with a p–i–n narrow-bandgap subcell (1.25 eV) resulted in a four-terminal triple-junction device with 28% efficiency.

Technical Details

To address the stringent material constraints of monolithic n–i–p integration, the researchers utilized a 2.0 eV Cs-based all-inorganic wide-bandgap subcell. The team implemented an additive-free P3HT hole-selective contact, which was reconfigured using MeO-2PACz to enhance molecular organization and promote efficient hole extraction.

Additional optimizations included:

- PCBM modification of the ALD-SnO_2 electron-selective contact in the 1.55 eV bottom subcell.
- Engineering of the interconnection layer to balance carrier coupling and suppress charge accumulation and voltage loss.
- Selection of materials for the wide-bandgap top subcell and hole-selective contact capable of withstanding bottom-subcell fabrication temperatures.

Background & Context

While all-perovskite tandem solar cells offer the potential for ultrahigh efficiencies, monolithic devices have predominantly used the p–i–n architecture. The n–i–p architecture is more challenging because the preformed top subcell must remain stable during the subsequent fabrication of the bottom subcell, which typically involves high temperatures that limit material choices.

Significance & Outlook

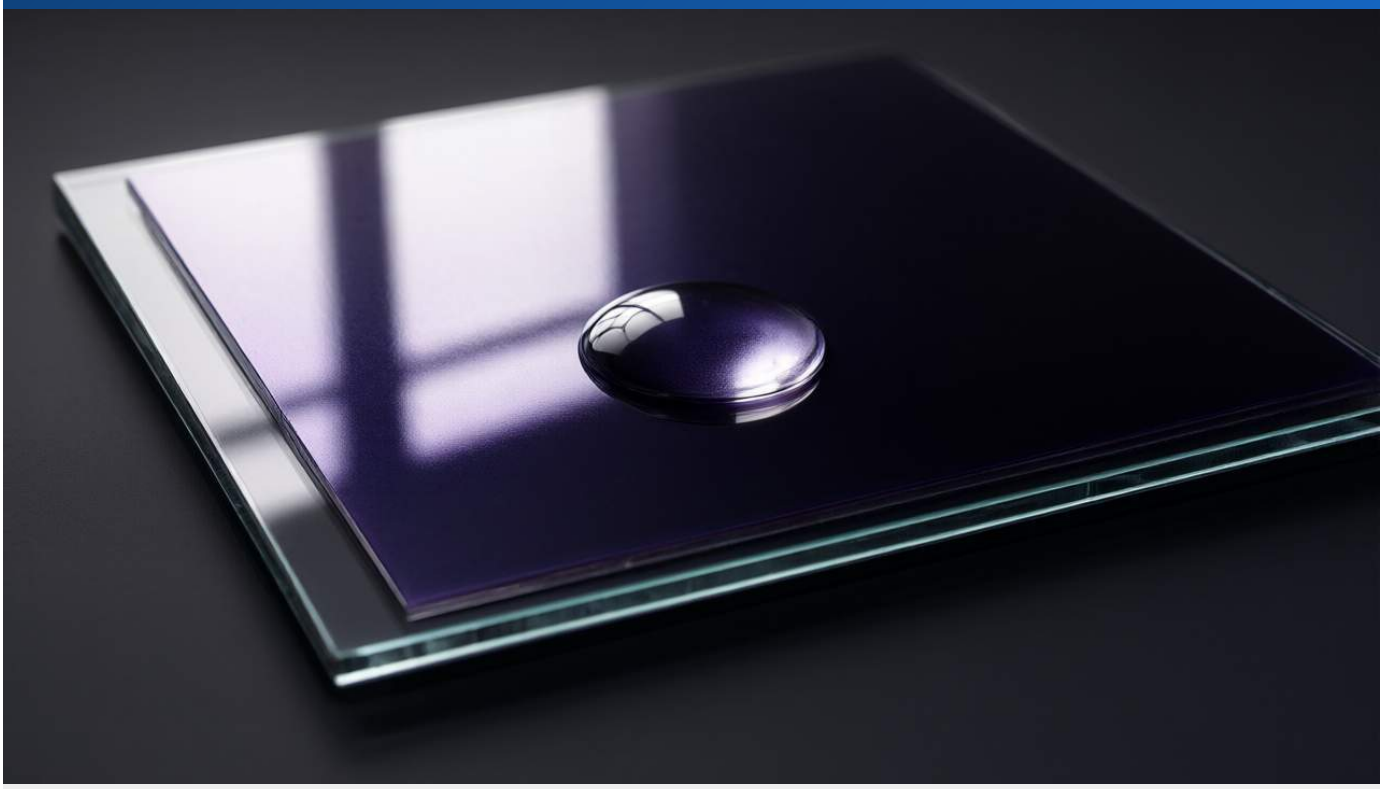
By alleviating the transport bottleneck in monolithic n–i–p tandems through interfacial modification, this work advances the viability of n–i–p architectures. The achievement of 25.3% efficiency in double-junction and 28% in triple-junction configurations demonstrates a significant step forward in perovskite tandem technology.

Source: https://www.nature.com/articles/s41467-026-79553-y

Collected: November 21, 2026 | Automated Research System (AI)

#05 Benzeneseleninic Acid: Boosting Perovskite Solar Cell Efficiency to 26.56%

Published November 19, 2026 BIOENGINEER China



OVERVIEW

Researchers have developed an interfacial chemical reconstruction strategy using benzeneseleninic acid to increase the power conversion efficiency of formamidinium-based perovskite solar cells from 23.68% to 26.56%. This multifunctional approach addresses stability bottlenecks by passivating interface defects and creating a hydrophobic barrier against environmental degradation.

IN DEPTH

Key Findings

A research team led by Yiqiang Zhang and Shasha Zhang from Zhengzhou University, in collaboration with Yanlin Song from the Institute of Chemistry at the Chinese Academy of Sciences, has achieved a verified power conversion efficiency of 26.56% in formamidinium-based perovskite solar cells, compared to 23.68% in control devices. The treatment improved the open-circuit voltage from 1.162 volts to 1.195 volts and the fill factor from 78.72% to 84.58%. Additionally, the current-voltage hysteresis factor was reduced from 2.5% to 0.8%.

Technical Details

The strategy utilizes benzeneseleninic acid ($C_6H_5SeO_2H$) as a multifunctional interfacial regulator. Upon deposition, the seleninic acid moiety deprotonates and forms bidentate lead-oxygen-selenium chelate structures with under-coordinated divalent lead ions. This mechanism provides several technical advantages:

- **Defect Passivation:** Trap-state density decreased by approximately 23%, and charge carrier lifetime increased from 144 nanoseconds to 330 nanoseconds.
- **Chemical Conversion:** The process suppresses the chemical reduction of divalent lead and converts excess residual lead iodide phases.
- **Environmental Shielding:** Outward-oriented hydrophobic phenyl groups form a barrier against moisture and oxygen.
- **Lattice Stabilization:** Residual protonated groups interact with formamidinium cations via hydrogen bonding, suppressing ion migration.

Background & Context

While formamidinium-based perovskites have seen efficiency gains from 3.8% to over 27%, commercialization is hindered by interface defects. Conventional monodentate Lewis-base passivators often fail to simultaneously address defect passivation, residual-phase conversion, and environmental shielding.

Significance & Outlook

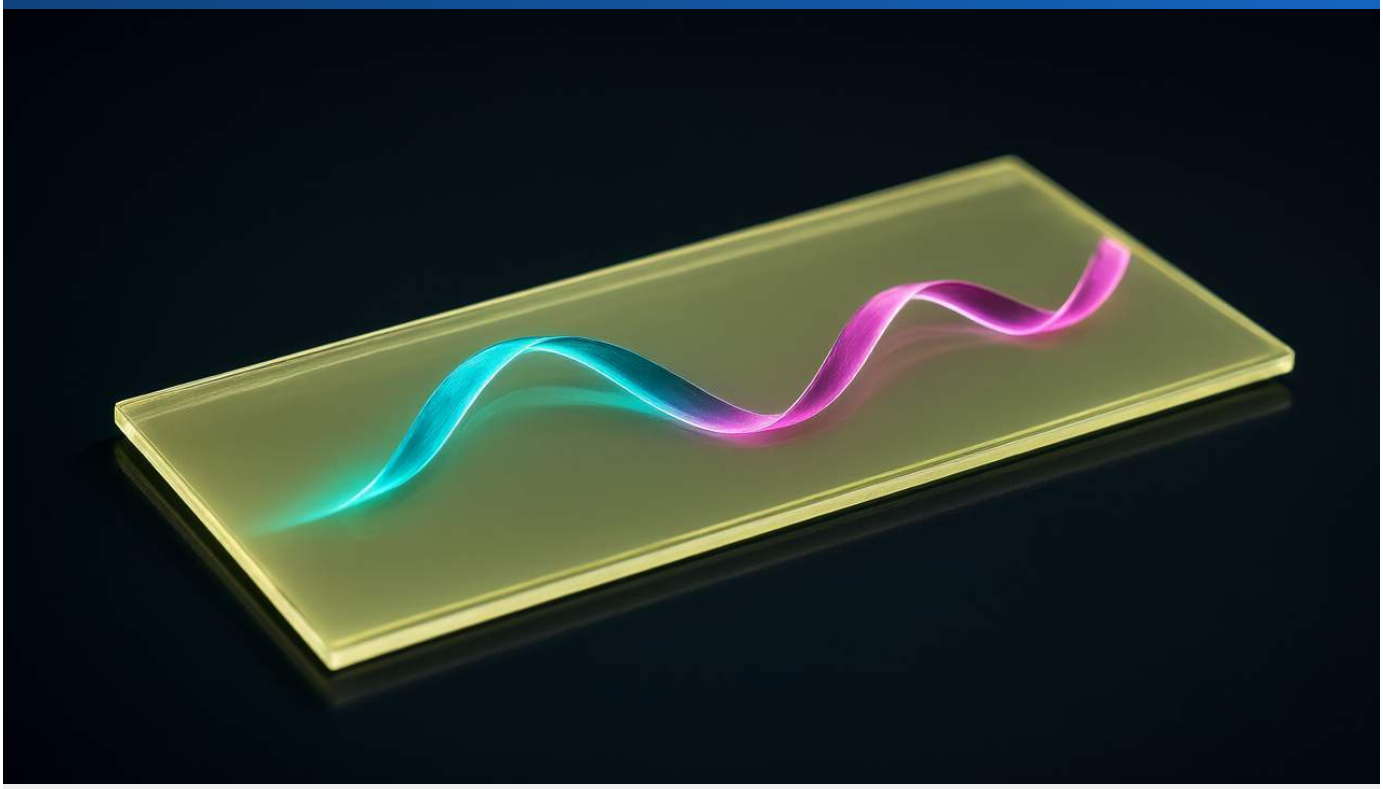
The modification significantly enhances durability without encapsulation. Unencapsulated treated cells retained 87.8% efficiency after 2000 hours at 25°C and 60% relative humidity, while controls dropped to 47.1% within 1000 hours. Thermal testing at 65°C showed 82.6% retention after 1600 hours versus 50.6% for controls. Published in *Materials Futures*, the study suggests a paradigm for combining chemical reconstruction with lattice stabilization. Future work will explore benzeneseleninic acid derivatives, selenium-containing polymer ligands, and buried interface applications.

Source: https://bioengineer.org/benzeneseleninic-acid-interfacial-strategy-boosts-perovskite-solar-cell-efficiency-to-26-56-percent/

Collected: November 21, 2026 | Automated Research System (AI)

#06 One-Dimensional Spiral Perovskites: Circular Polarization Sensing

Published November 19, 2026　日本経済新聞（プレスリリース）　Japan



OVERVIEW

A research group from Waseda University, the National Institute of Advanced Industrial Science and Technology, and Tokyo University of Science has developed a semiconductor thin film capable of identifying the rotation direction of light and generating photocurrent without external voltage. The material achieves a circular polarization discrimination ratio of approximately 105 and a photovoltage of about 2V.

IN DEPTH

Key Findings

Researchers have developed a semiconductor thin film that can identify the rotation direction of light as an electrical signal and generate photocurrent without the need for an external voltage source. The developed film demonstrates a circular polarization discrimination ratio—the difference in photocurrent between right-handed and left-handed circularly polarized light—of up to approximately 105. Additionally, the material produced a photovoltage of approximately 2V without utilizing the pn junctions typically found in conventional solar cells.

Technical Details

The material used is a "one-dimensional spiral perovskite semiconductor," which combines organic molecules and inorganic semiconductors. The research team achieved the following technical milestones:

- **Structural Control:** By optimizing the structure of organic molecules, the team controlled the crystal symmetry and alignment while maintaining the internal spiral structure of the semiconductor.
- **Fabrication Method:** The team successfully produced thin films that retain these specific crystal structure characteristics using a solution-based coating method.

Background and Context

The study demonstrates that different photoelectric conversion functions can be integrated into a single material through the design of organic molecules. This approach allows for the simultaneous control of the semiconductor's crystal structure and its photoelectric conversion capabilities. The findings were published in the international academic journal *Advanced Science* on November 15, 2026.

Significance and Outlook

This development indicates a path toward creating multifunctional optoelectronic devices that reduce dependence on external power sources. Potential applications include high-sensitivity circular polarization sensors and low-power consumption optical sensors.

Source: https://www.nikkei.com/article/DGXZRSP715521_Z11C26A1000000/

Collected: November 21, 2026 | Automated Research System (AI)

#07 Sirius PV: 525 W Perovskite Tandem Modules and 2027 Roadmap

Published November 19, 2026 pv magazine International USA



OVERVIEW

Sirius PV has introduced the HybridTandem residential solar module, achieving 525 W DC using Caelux's Energy Producing Glass. The company also partnered with IronRidge to integrate EPIC Aire compatible frames to reduce residential installation time by up to 30%.

IN DEPTH

Key Findings

Sirius PV has introduced new residential solar products and partnerships with Caelux and IronRidge, debuted at RE+ 2026 in Las Vegas. The primary development is the HybridTandem residential solar module, which delivers 525 W DC under standard test conditions. This represents a power increase over the company's existing 450 W residential modules while maintaining the same footprint.

Technical Details

The HybridTandem module utilizes Caelux's Energy Producing Glass to achieve its power rating. According to Caelux CEO Scott Graybeal, the company's roadmap targets an increase in the power output of its perovskite thin-film glass by more than 26% by 2030. Sirius PV is currently completing the necessary testing and certification processes before the product is released to customers.

In addition to cell efficiency, Sirius PV is updating its hardware integration through a partnership with IronRidge. The company is integrating module frames compatible with IronRidge's EPIC Aire universal mid-and-end clamps. This system employs a hinge-and-lock mechanism designed to streamline the installation process on residential rooftops.

Timeline and Availability

The rollout of the EPIC-compatible frames will occur in two phases:

- First half of 2027: Limited quantities available.
- Second half of 2027: Widespread availability across the Sirius PV product portfolio.

Two HybridTandem modules featuring the EPIC-compatible frame are currently on display at the BayWa r.e. booth at the RE+ show.

Significance and Outlook

The integration of EPIC-compatible frames is expected to make solar installations up to 30% faster, which Sirius PV states will significantly reduce labor costs and improve productivity for installers. The adoption of perovskite tandem technology marks a shift toward higher power density in the residential sector, following a similar move by Minnesota-based module maker Heliene, which introduced a utility-scale module using Caelux glass shortly before RE+.

Source: https://www.pv-magazine.com/2026/11/19/sirius-pv-unveils-525-w-perovskite-tandem-residential-modules-debuts-ironridge-partnership/

Collected: November 21, 2026 | Automated Research System (AI)

#08 Perovskite Stability: Nanodiamonds and Mechanical Heterogeneity

Published November 20, 2026 腾讯新闻（中国新闻网） China



OVERVIEW

Researchers at Zhejiang University have achieved a certified steady-state power conversion efficiency of 27.04% by incorporating nanodiamonds into perovskite thin films. This approach addresses stability issues by mitigating mechanical heterogeneity and stress concentration at grain boundaries, significantly extending operational lifespan.

IN DEPTH

Key Findings

A research team from the State Key Laboratory of Silicon and Advanced Semiconductor Materials at Zhejiang University has developed a method to enhance the stability and efficiency of perovskite solar cells. By introducing nanodiamonds into the perovskite thin film, the team achieved a certified steady-state photoelectric conversion efficiency of 27.04%. Additionally, small-scale modules measuring 16.1 square centimeters reached an efficiency of 24.3%.

Technical Details

The study, published in the journal *Science* on November 20, 2026, identifies "mechanical heterogeneity" as a primary cause of instability in perovskite's "soft lattice" structure. Using an in-situ nanoindentation platform at the Zhejiang University Hangzhou International Innovation Center, the team discovered that creep at grain boundaries is significantly higher than within the grain interiors under the same load. This disparity causes the material to degrade during the repeated thermal expansion and contraction associated with day-night temperature cycles.

To resolve this, the team utilized diamond particles with an average diameter of approximately 10 nanometers as reinforcing agents. These nanodiamonds restructure the elastic field of the thin film, redistributing stress more uniformly across the film rather than concentrating it at the grain boundaries, thereby increasing the deformation resistance of the boundaries.

Background and Context

Perovskites are synthetic semiconductor materials capable of rapid production via solution processing. While laboratory efficiencies for single-junction small-area cells have reached 28%—comparable to silicon—and theoretical limits for tandem cells reach 46%, stability remains the primary barrier to industrialization. The "soft lattice" nature of the material makes it susceptible to mechanical failure from repeated thermal stress.

Significance and Outlook

The integration of nanodiamonds demonstrates a substantial improvement in long-term durability. In simulated day-night light cycle tests lasting 5,000 hours, the diamond-reinforced cells maintained over 90% of their initial efficiency, whereas the control group decayed to approximately 50%.

Source: https://news.qq.com/rain/a/20261120A0CQA700

Collected: November 21, 2026 | Automated Research System (AI)

#09 Perovskite Solar Cells: Xi'an Jiaotong University's 27.96% Efficiency Interface Solution

Published November 20, 2026　凤凰网（西安晚报）　China



OVERVIEW

Researchers at Xi'an Jiaotong University have developed a new interface control technology using heteroatom-containing fully conjugated formamidinium molecules to simultaneously improve efficiency and stability. The method achieved a 27.96% photoelectric conversion efficiency in single-junction cells and 34.74% in perovskite-silicon tandem cells.

IN DEPTH

Key Findings

A research team led by the State Key Laboratory of Metal Materials Strength at Xi'an Jiaotong University has developed a novel interface control technology for perovskite solar cells. This approach creates a band-edge extended heterojunction interface, resulting in a single-junction perovskite solar cell with a photoelectric conversion efficiency of 27.96% and a steady-state power generation efficiency of 27.84%.

Technical Details

The team addressed the industry challenge of balancing defect repair with rapid charge transport. To solve this, they designed a series of fully conjugated formamidinium interface control molecules containing heteroatoms. This molecular design repairs interface defects and reduces energy loss while establishing efficient electronic transport channels.

The technology demonstrates broad applicability across different cell architectures:

- **Single-junction cells:** Achieved 27.96% conversion efficiency and 27.84% steady-state efficiency.
- **Perovskite-silicon tandem cells:** Achieved a power generation efficiency of 34.74% and a steady-state efficiency of 34.71%, with key performance exceeding 2 volts.

Regarding durability, unencapsulated modified devices maintained over 95% of their initial power generation efficiency after 2,000 hours of continuous operation under light exposure at approximately 45°C.

Background & Context

Perovskite solar cells are a leading technology in the photovoltaic sector, but their commercialization has been hindered by the difficulty of simultaneously optimizing interface defect repair and charge transport. These factors have historically limited both the power generation efficiency and the operational lifespan of the devices.

Significance & Outlook

By overcoming the trade-off between efficiency and stability, this technical solution provides a new framework for the development and mass production of high-efficiency, long-life, and low-cost solar cells. The results establish a foundation for the industrial application of next-generation photovoltaic technologies.

Source: https://feng.ifeng.com/c/8yCOmWq7zSH

Collected: November 21, 2026 | Automated Research System (AI)

#10 Perovskite Tandem Cells: Efficiency Gains vs Lead Sustainability

Published November 19, 2026 CGTN China



OVERVIEW

Chinese firms are accelerating tandem cell efficiency, with records reaching 35.5%, but lead-based toxicity remains a critical barrier. While recycling methods and lead-free alternatives are being explored, the lack of standardized green regulations threatens mass-market viability.

IN DEPTH

Key Findings

China's race for perovskite tandem efficiency is accelerating, as evidenced by recent data from the 9th China International PV & Storage Industry Conference in Chengdu. JinkoSolar reported a 35.24% TOPCon/perovskite tandem cell, while LONGi reported 35.5% in July, alongside a 34.3% efficiency on 261 square centimeters and a 100-megawatt pilot line. Additionally, Nanjing University and Renshine claimed 26.2% on a 65 sqcm all-perovskite module, and a 3.1-sqm tandem module reached 29.2% and 907 W.

Technical Details

Despite efficiency gains, high performance remains dependent on lead. Lead-free alternatives lag significantly; flexible lead-free cells reached only 4.95%, and tin-based perovskites face instability and oxidation issues. To mitigate lead risks, several recovery methods have been identified:

- Ultrasonic water leaching: Removes over 99.8% of lead with a net economic benefit of approximately $4.735 per sqm.
- Aqueous routes: Costs can fall below $3 per sqm.
- Upcycling: Researchers from Julich, Germany, converted old lead bullets into photovoltaic-grade Lead diiodide with a 94% yield, producing cells at around 21%.

Background & Context

Industry experts warn that mass production may be premature. Shen Hui of the Yangtze Institute for Solar Technology emphasized that true capability is measured by average mass-production module efficiency and reliability rather than record-breaking cells measured under specific conditions. Furthermore, while China leads in efficiency, it still relies on foreign institutions for authoritative certification. Martin Green has cautioned that perovskite stability issues may take a decade to solve, or may never be resolved, leading to the launch of the first third-party outdoor testing program.

Significance & Outlook

China occupies a dual position as the fastest industrializer and the region with the largest potential exposure to lead externalities. The industry currently lacks mandatory encapsulation limits, recycling responsibility, and cross-border regulatory recognition. Establishing green standards—including leakage limits and closed-loop lead management—is now a structural necessity for the technology's long-term adoption.

Source: https://news.cgtn.com/news/2026-11-19/Beyond-efficiency-Perovskite-s-green-ledger-remains-unbalanced-1ScPEMB6kFy/p.html

Collected: November 21, 2026 | Automated Research System (AI)

#11 Perovskite-Silicon Tandems: Vacuum Deposition and 30.3% Efficiency

Published November 17, 2026 Welt der Physik Germany



OVERVIEW

Researchers have developed a vacuum evaporation process using a cesium chloride primer to achieve uniform perovskite growth on textured silicon surfaces. This method has demonstrated a solar cell efficiency of 30.3%, overcoming the limitations of traditional solution-based deposition.

IN DEPTH

Key Findings

A new production method for perovskite-silicon tandem solar cells has achieved an efficiency of 30.3%. By utilizing a vacuum evaporation process combined with a specific primer layer, researchers have addressed the challenge of uneven crystal growth on the rough surfaces of industrial silicon wafers.

Technical Details

Industrial silicon plates feature a surface covered in tiny pyramids, several dozen micrometers high, designed to increase sunlight absorption through internal reflection. While traditional solution-based deposition fails because the solvent collects in the "valleys" of these pyramids, leading to uneven growth, the vacuum evaporation method also faces irregularities due to this structure.

To resolve this, the team introduced a thin layer of cesium chloride on the silicon before the perovskite deposition. This primer ensures a more uniform and well-defined growth of perovskite crystals, as the cesium chloride prevents the material from sliding off the flanks of the silicon pyramids. During the growth phase, the cesium chloride becomes part of the perovskite layer. The molecular-level effects of this layer were analyzed using the BESSY II synchrotron source in Berlin.

Background and Context

Standard silicon solar cells have a commercial efficiency of slightly over 20% and a laboratory peak of approximately 28%, nearing the theoretical maximum of 29.4%. Perovskite crystals can be applied in ultra-thin layers to act as absorbers for specific wavelengths without interfering with the silicon. This tandem configuration raises the theoretical efficiency maximum to approximately 43%.

However, perovskites face stability issues, as they degrade quickly when exposed to oxygen and moisture, requiring hermetic sealing. Additionally, complex contact layers are necessary to allow charge carriers to move between the two materials.

Significance and Outlook

While the 30.3% efficiency is promising, the process is not yet ready for industrial application. Current growth rates in the vacuum evaporation process are too low for mass production compared to more established solution-based methods. Future development must focus on increasing production speed and ensuring the process is cost-effective and reliable.

Source: https://www.weltderphysik.de/gebiet/technik/energie/solarenergie/photovoltaik/gleichmaessiges-wachstum-von-perowskit-auf-silizium/

Collected: November 21, 2026 | Automated Research System (AI)