

TROY TECHNICAL

PEROVSKITE SOLAR CELLS

WEEKLY REPORT

September 19 - September 25, 2026 | Issue 2026-W38

**Bankable module performance, durability,
manufacturing yield and market entry**

14

ANALYZED ARTICLES

10

PRIORITY THEMES

Issued 2026-09-25 | English edition | fixed approved cover artwork



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

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

SIGNAL 01 | PRECURSORS

Renshine Solar: Meter-scale perovskite scalability explained

Nanjing University and Renshine Solar announced in Nature in August 2026 a breakthrough addressing the scalability problem of perovskite solar cells at meter-scale.

SIGNAL 02 | CELL STACK

Nanjing University: 33.3% efficient tandem cell ambient process

Researchers at Nanjing University in China developed a novel polymeric hole transport layer (HTL) for a perovskite-silicon tandem solar cell, achieving 33.3% efficiency and enabling ambient air processing.

SIGNAL 03 | MODULE PROCESS

Trina Solar: 29.2% efficiency specs for 3.1 m2 tandem module

Trina Solar announced in June 2026 a new world record for full-area module efficiency, achieving 29.2% with a large 3.1 square meter perovskite/crystalline silicon tandem module.

SIGNAL 04 | QUALIFICATION

Suzhou University: Perovskite/Silicon tandem 34% efficiency specs

Researchers at Suzhou University in China achieved a 34.0% power conversion efficiency for perovskite/silicon tandem solar cells, independently certified at 33.5% steady-state efficiency.

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.

Five numbers or evidence anchors that require conditions

35.5%

A12

SOURCE-BOUND CONDITION

LONGi certified a 35.5% perovskite-silicon tandem in July 2026, and the same Nanjing team's all-perovskite tandems have exceeded 30.1% efficiency.

33.3%

A05

SOURCE-BOUND CONDITION

Researchers at Nanjing University in China developed a novel polymeric hole transport layer (HTL) for a perovskite-silicon tandem solar cell, achieving 33.3% efficiency and enabling ambient air processing.

29.2%

A09

SOURCE-BOUND CONDITION

Trina Solar announced in June 2026 a new world record for full-area module efficiency, achieving 29.2% with a large 3.1 square meter perovskite/crystalline silicon tandem module.

34.0%

A04

SOURCE-BOUND CONDITION

Researchers at Suzhou University in China achieved a 34.0% power conversion efficiency for perovskite/silicon tandem solar cells, independently certified at 33.5% steady-state efficiency.

16.19%

A02

SOURCE-BOUND CONDITION

research team achieved 16.19% power conversion efficiency with a 2D/3D hybrid tin-based perovskite solar cell, simultaneously setting a new industry-leading stability record.

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
Nanjing University and Renshine Solar announced in Nature in August 2026 a breakthrough addressing the scalability problem of.

2

Cell stack
P02/P07
Researchers at Nanjing University in China developed a novel polymeric hole transport layer (HTL) for a perovskite-silicon.

3

**Module proce
ss**
P03/P08
Trina Solar announced in June 2026 a new world record for full-area module efficiency, achieving 29.2% with a large 3.1.

4

Qualification
P04/P09
Researchers at Suzhou University in China achieved a 34.0% power conversion efficiency for perovskite/silicon tandem solar.

5

**Deployment
& recycling**
P05/P10
A U.S.

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



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

Renshine Solar: Meter-scale perovskite scalability explained

A12 | Precursors | Research

Date not stated

FACT

Nanjing University and Renshine Solar announced in Nature in August 2026 a breakthrough addressing the scalability problem of perovskite solar cells at meter-scale. This achievement overcomes a long-standing challenge in applying high efficiencies from small cells to large modules, marking a significant step towards commercialization. LONGi certified a 35.5% perovskite-silicon tandem in July 2026, and the same Nanjing team's all-perovskite tandems have exceeded 30.1% 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 P01.

UNKNOWN

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

EDITORIAL SCORE 21/25 | MATURITY 1/5 | DECISION LOCUS: SYSTEM / ADOPTION

P02

Nanjing University: 33.3% efficient tandem cell ambient process

A05 | Cell stack | Pilot

Date not stated

FACT

Researchers at Nanjing University in China developed a novel polymeric hole transport layer (HTL) for a perovskite-silicon tandem solar cell, achieving 33.3% efficiency and enabling ambient air processing. The device recorded an independently certified efficiency of 33.0%, with the PNCC copolymer exhibiting excellent wettability and high film uniformity that facilitates homogeneous perovskite deposition. This breakthrough paves the way for large-scale, low-cost manufacturing of high-efficiency solar 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 P02.

UNKNOWN

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

EDITORIAL SCORE 21/25 | MATURITY 2/5 | DECISION LOCUS: TECH / PROCESS

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

P03

Trina Solar: 29.2% efficiency specs for 3.1 m2 tandem module

A09 | Module process | Research

Date not stated

FACT

Trina Solar announced in June 2026 a new world record for full-area module efficiency, achieving 29.2% with a large 3.1 square meter perovskite/crystalline silicon tandem module. This achievement marks a significant milestone for the commercialization of perovskite technology, demonstrating its potential for high efficiency at a practical scale. The company's R&D efforts are accelerating the commercial deployment of next-generation solar cell technology.

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 21/25 | MATURITY 1/5 | DECISION LOCUS: SYSTEM / ADOPTION

P04

Suzhou University: Perovskite/Silicon tandem 34% efficiency specs

A04 | Qualification | Pilot

Date not stated

FACT

Researchers at Suzhou University in China achieved a 34.0% power conversion efficiency for perovskite/silicon tandem solar cells, independently certified at 33.5% steady-state efficiency. This device recorded an unprecedented 2.014V open-circuit voltage, the highest ever for this class of solar cells. The introduction of a nano-scaffold structure suppressed non-uniform perovskite growth and non-radiative recombination at interfaces, significantly enhancing both efficiency and durability.

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

Tin Perovskite: US team's 16.19% efficiency and stability record

A02 | Deployment & recycling | Research

Date not stated

FACT

A U.S. research team achieved 16.19% power conversion efficiency with a 2D/3D hybrid tin-based perovskite solar cell, simultaneously setting a new industry-leading stability record. This lead-free device maintained 95% of its initial efficiency after 1600 hours in dry air and 80% after 1000 hours under continuous illumination at 55°C. The use of chlorinated spacers significantly enhanced crystallinity and resistance to oxygen and moisture.

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: TECH / PROCESS

P06

Tin Perovskite: Hot electron specs for 33% efficiency in 2026

A01 | Precursors | Research

Date not stated

FACT

A groundbreaking discovery in tin-based perovskite materials reveals 'hot electrons' retaining their excess energy for nanoseconds, a 1000-fold increase over conventional picosecond durations. This extended lifetime could enable the development of next-generation solar cells surpassing the theoretical 33% efficiency limit. The unique charge carrier cooling mechanism within the material is identified as key to this efficiency breakthrough.

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 1/5 | DECISION LOCUS: TECH / PROCESS

Troy Technical | Perovskite Solar Cells | cutoff 2026-09-25

08

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

P07

Perovskite solar cells: 10m underwater power specs for China

A11 | Cell stack | Scale-up

Date not stated

FACT

A team of Chinese scientists successfully deployed wide-bandgap perovskite solar cells 10 meters underwater off Weizhou Island, generating 324 mWh of power. This technology aims to overcome corrosion and continuously power subsea sensors and unmanned vehicles, significantly expanding China's offshore surveillance capabilities. Tuned to efficiently utilize blue-green light, this breakthrough enhances stability in marine environments.

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 5/5 | DECISION LOCUS: SYSTEM / ADOPTION

P08

Perovskite solar cells: Underwater specs for 2026 marine drones

A06 | Module process | Research

Date not stated

FACT

TechRadar featured groundbreaking research where Chinese scientists successfully operated perovskite solar cells at a depth of 10 meters, generating electricity underwater. This technology is optimized to efficiently utilize blue-green light, which penetrates water effectively, and is expected to enable self-powered marine observation equipment and underwater drones for long-term operation. This achievement has the potential to solve energy supply challenges in marine technology.

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

Perovskite Solar: Asymmetric molecules for 25.6% efficiency

A03 | Qualification | Pilot

Date not stated

FACT

An international research team developed a 'symmetry-breaking co-assembly approach' for perovskite solar cells, incorporating asymmetric molecules to achieve over 25.6% certified efficiency and long-term stability. This method combines a common symmetric self-assembled monolayer (SAM) with a simple asymmetric molecule, suppressing molecular self-aggregation and significantly improving surface coverage and buried interface quality. This optimization of charge transport dramatically boosts device performance.

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: 2026 defect suppression specs

A13 | Deployment & recycling | Research

Date not stated

FACT

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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 1/5 | 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 01-07

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	Tin Perovskite: Hot electron specs for 33% efficiency in 2026	https://www.perovskite-info.com/long-lived-hot-electrons-tin-perovskites-could-push-solar-cells-past-33
A02	Tin Perovskite: US team's 16.19% efficiency and stability record	https://www.pv-magazine.com/2026/09/25/us-team-claims-stability-record-for-16-19-efficient-2d-3d-tin-perovskite-solar-cell/
A03	Perovskite Solar: Asymmetric molecules for 25.6% efficiency	https://www.thecooldown.com/green-tech/perovskite-solar-cell-efficiency-improvement/
A04	Suzhou University: Perovskite/Silicon tandem 34% efficiency specs	https://www.eurekalert.org/news-releases/1144549
A05	Nanjing University: 33.3% efficient tandem cell ambient process	https://www.pv-magazine.com/2026/09/21/chinese-scientists-build-33-3-efficient-perovskite-silicon-tandem-solar-cell-processed-in-ambient-air/
A06	Perovskite solar cells: Underwater specs for 2026 marine drones	https://www.techradar.com/home/energy-saving/scientists-test-underwater-solar-panels-that-work-10-meters-beneath-the-waves-breakthrough-perovskite-tech-could-support-self-powered-marine-drones
A07	Perovskite photovoltaics: Indoor efficiency engineering explained	https://www.perovskite-info.com/higher-efficiency-indoor-perovskite-photovoltaics-bandgap-solvent-and

ANALYZED ARTICLES | ITEMS 08-14

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
A08	All-perovskite tandem cells: Solid-state conversion pathways	https://arxiv.org/abs/2609.20326
A09	Trina Solar: 29.2% efficiency specs for 3.1 m2 tandem module	https://finance.biggo.com/news/14981380-7fd2-4f1d-b9d5-3d0dbe2c785f
A10	Cs2SnI6 Perovskite: Lead-free stability vs water and oxygen	https://www.perovskite-info.com/new-study-predicts-long-term-stability-lead-free-perovskite-against-water-and
A11	Perovskite solar cells: 10m underwater power specs for China	https://energygeopoliticsandstatecraft.substack.com/p/submerged-power-surface-control-chinas
A12	Renshine Solar: Meter-scale perovskite scalability explained	https://biznewsbyjay.substack.com/p/37-why-does-india-import-100-of-its
A13	Perovskite solar cells: 2026 defect suppression specs	https://bioengineer.org/bulky-molecules-keep-rival-defect-fighters-from-cancelling-each-other-out-in-perovskite-solar-cells/
A14	University of Toledo: Lead-free perovskite stability roadmap	https://news.utoledo.edu/index.php/09_22_2026/utoledo-physicists-lend-expertise-to-research-advancing-solar-energy-technology

PerovskiteSolarCells — Selected Articles

Date: 2026-09-27

Articles: 14

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#01 Tin Perovskite: Hot electron specs for 33% efficiency in 2026

Published September 24, 2026 Perovskite-Info.com International研究



OVERVIEW

A groundbreaking discovery in tin-based perovskite materials reveals 'hot electrons' retaining their excess energy for nanoseconds, a 1000-fold increase over conventional picosecond durations. This extended lifetime could enable the development of next-generation solar cells surpassing the theoretical 33% efficiency limit. The unique charge carrier cooling mechanism within the material is identified as key to this efficiency breakthrough.

Key Findings

Recent international research has unveiled a significant breakthrough in lead-free tin-based perovskite solar cell materials, demonstrating that 'hot electrons' generated by light illumination can retain their excess energy for nanoseconds, a dramatic extension from conventional picosecond durations. This 1000-fold increase in lifetime holds the potential to enable the development of next-generation solar cells exceeding the theoretical efficiency limit of 33%, marking a substantial advancement for solar energy technology.

Technical / Clinical Details

Researchers discovered that this prolonged hot electron lifetime is attributed to a unique charge carrier cooling mechanism within tin-based perovskites. Specifically, the process by which electrons lose energy to lattice vibrations (phonons) is dramatically slowed, allowing them to remain in a high-energy state for longer periods. This increases the opportunity for electrons to extract more energy from the harvesting layer, consequently boosting the device's power conversion efficiency. This innovation opens up a new energy conversion pathway, previously unattainable with traditional silicon-based solar cells, allowing for the utilization of a broader solar spectrum.

Background & Context

Perovskite solar cells are gaining significant attention as a next-generation solar technology due to their high efficiency and low manufacturing costs. However, improving the efficiency and stability of lead-free materials has been a persistent challenge. The concept of utilizing hot electrons has been studied for years as a potential route to break through the Shockley-Queisser limit of silicon solar cells, but demonstrating this effect with practical lifetimes in actual materials has been difficult. This discovery is critically important for the industry as it provides a concrete pathway to overcome this challenge using environmentally friendlier tin-based perovskites.

Strategic Significance & Outlook

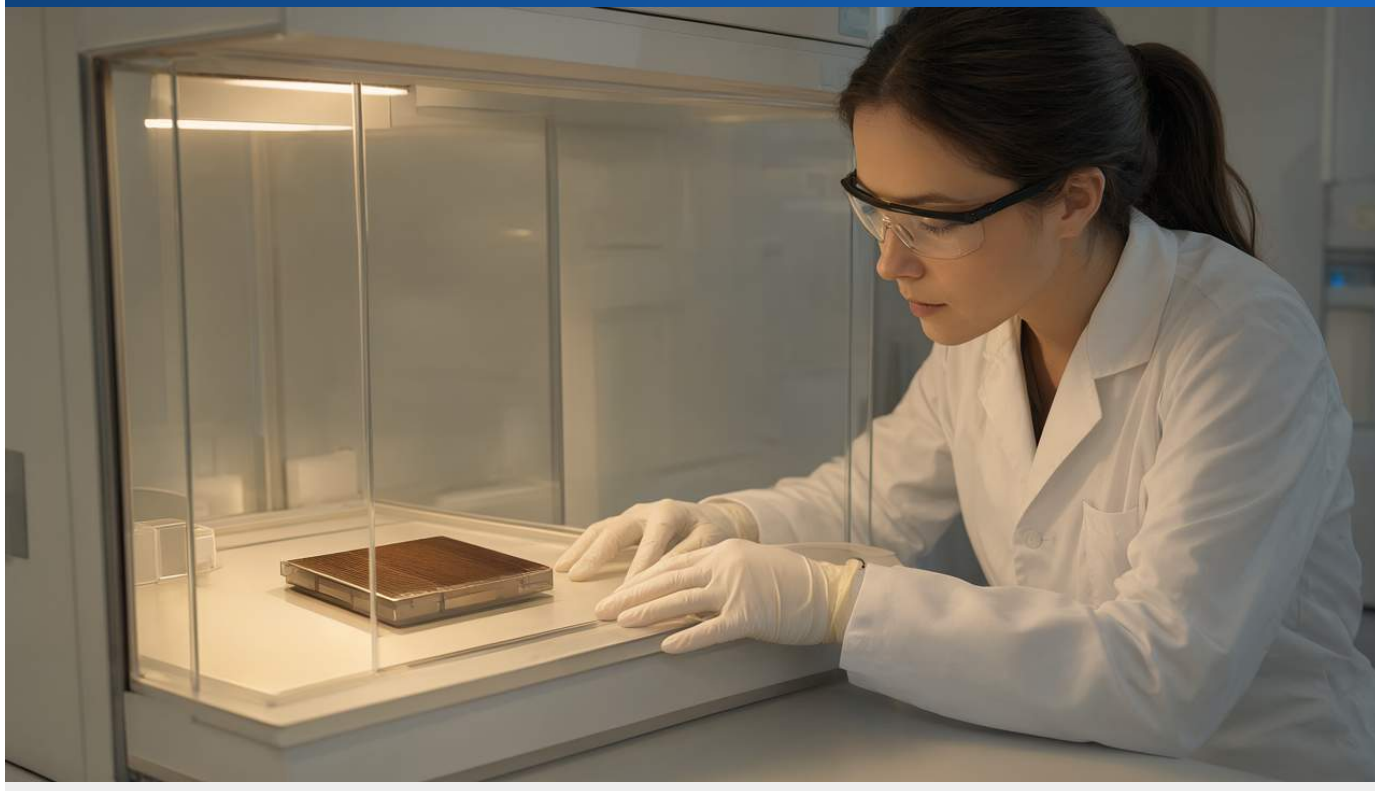
This finding is expected to accelerate research and development in optimizing material design and device structures for tin-based perovskite solar cells to push efficiencies beyond 33%. If hot electron utilization technology can be commercialized, it would dramatically improve the cost-effectiveness of solar power generation and further propel the transition to clean energy. In the future, it is anticipated to contribute to the widespread adoption of higher-performance, more sustainable solar cells and serve as a catalyst for innovation in the energy sector.

Source: <https://www.perovskite-info.com/long-lived-hot-electrons-tin-perovskites-could-push-solar-cells-past-33>

Collected: September 25, 2026 | Automated Research System (Gemini API)

#02 Tin Perovskite: US team's 16.19% efficiency and stability record

Published September 25, 2026 PV Magazine USA



OVERVIEW

A U.S. research team achieved 16.19% power conversion efficiency with a 2D/3D hybrid tin-based perovskite solar cell, simultaneously setting a new industry-leading stability record. This lead-free device maintained 95% of its initial efficiency after 1600 hours in dry air and 80% after 1000 hours under continuous illumination at 55°C. The use of chlorinated spacers significantly enhanced crystallinity and resistance to oxygen and moisture.

Key Findings

A U.S. research team has achieved a high power conversion efficiency of 16.19% with an environmentally friendly, lead-free tin-based perovskite solar cell, while simultaneously establishing a world record for long-term stability. This 2D/3D hybrid perovskite solar cell demonstrates a groundbreaking advance in both performance retention in dry air and durability under high-temperature continuous illumination.

Technical / Clinical Details

The developed device integrates two-dimensional (2D) and three-dimensional (3D) perovskite structures. A key innovation involves the introduction of chlorinated spacer molecules, which significantly improve the material's crystallinity and enhance its resistance to oxygen and moisture. This effectively suppresses degradation under ambient conditions. The specific stability data is remarkable: the device maintained 95% of its initial efficiency after more than 1600 hours in dry air and retained 80% efficiency after 1000 hours under harsh continuous illumination at 55°C. These figures represent an unprecedented achievement for tin-based perovskites and mark a critical milestone towards their practical application.

Background & Context

While perovskite solar cells have rapidly advanced in efficiency, material stability—particularly their vulnerability to ambient oxygen and moisture—has remained a significant hurdle for commercialization. Furthermore, concerns regarding the toxicity of lead have driven a strong demand for lead-free alternatives. Tin-based perovskites are a promising candidate for lead-free compositions, but their inherently lower stability has previously hindered practical adoption. This research addresses the industry's need for both environmentally conscious and high-performing solutions by demonstrating a lead-free tin-based perovskite that combines high efficiency with excellent stability.

Strategic Significance & Outlook

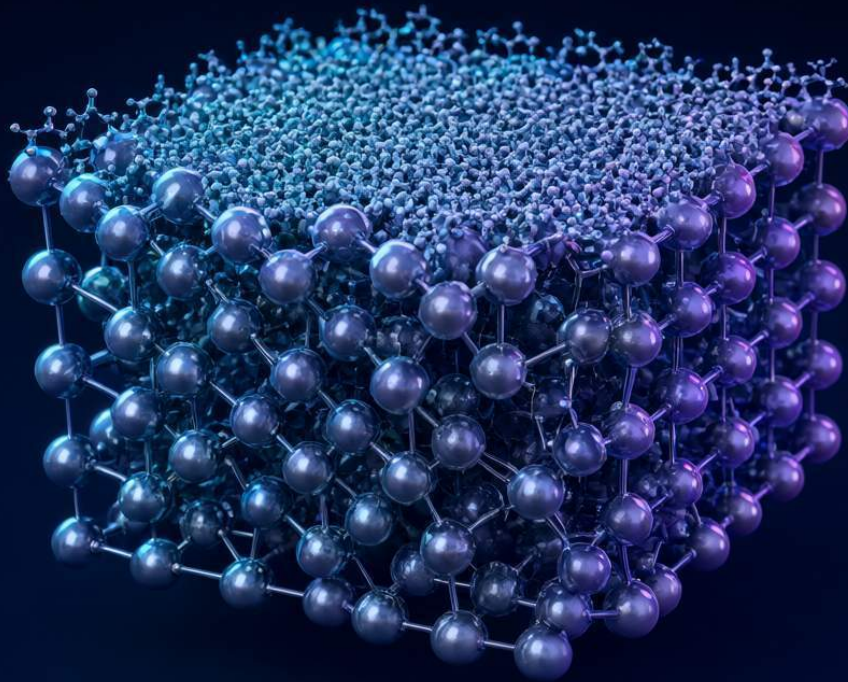
The establishment of this stability record represents a major step towards the commercialization of lead-free perovskite solar cells. As further efficiency improvements and cost reductions are achieved, their adoption is expected to accelerate across a wide range of markets, including residential, commercial, and specialized applications. Especially in an era of tightening environmental regulations, reliable and lead-free solar cell technology will significantly enhance market competitiveness and contribute to the widespread deployment of sustainable energy solutions.

Source: <https://www.pv-magazine.com/2026/09/25/us-team-claims-stability-record-for-16-19-efficient-2d-3d-tin-perovskite-solar-cell/>

Collected: September 25, 2026 | Automated Research System (Gemini API)

#03 Perovskite Solar: Asymmetric molecules for 25.6% efficiency

Published September 20, 2026 The Cool Down International研究



OVERVIEW

An international research team developed a 'symmetry-breaking co-assembly approach' for perovskite solar cells, incorporating asymmetric molecules to achieve over 25.6% certified efficiency and long-term stability. This method combines a common symmetric self-assembled monolayer (SAM) with a simple asymmetric molecule, suppressing molecular self-aggregation and significantly improving surface coverage and buried interface quality. This optimization of charge transport dramatically boosts device performance.

Key Findings

An international research team has developed a novel approach that dramatically enhances the performance of perovskite solar cells, achieving over 25.6% certified power conversion efficiency along with excellent long-term stability. This groundbreaking achievement was realized through a 'symmetry-breaking co-assembly approach' that introduces 'asymmetric molecules' at the interface between the perovskite layer and the charge transport layer.

Technical / Clinical Details

In this new approach, commonly used symmetric self-assembled monolayers (SAMs), such as MeO-2PACz, are co-assembled with a simple asymmetric molecule, DTCA. This combination effectively suppresses molecular self-aggregation, leading to a much more uniform and dense coverage across the entire perovskite surface and significantly reducing interface defects. As a result, non-radiative recombination of charge carriers is inhibited, and the extraction efficiency of electrons and holes is improved, leading to a substantial enhancement in the overall solar cell efficiency. Furthermore, the improved interface quality contributes to the long-term operational stability of the device, addressing a critical challenge for practical application.

Background & Context

While perovskite solar cells have rapidly achieved high photoelectric conversion efficiencies, charge losses at interfaces and low stability against environmental stress have been major barriers to commercialization. Crucially, precise control of the interface between the perovskite layer and the charge transport layer is paramount for determining device performance. Conventional SAMs faced challenges in forming uniform interfaces due to molecular self-aggregation, a problem fundamentally resolved by the introduction of asymmetric molecules in this research. This technology holds the potential to accelerate the widespread adoption of low-cost, high-performance perovskite solar cells.

Strategic Significance & Outlook

The 'symmetry-breaking co-assembly approach' provides new design guidelines for further improving the efficiency and stability of perovskite solar cells. It is expected that this approach will be applied to other perovskite material systems and device architectures, thereby elevating the overall technological level of the industry.

Consequently, perovskite solar cells will further enhance their competitiveness against traditional silicon solar cells, solidifying their position as a sustainable energy source.

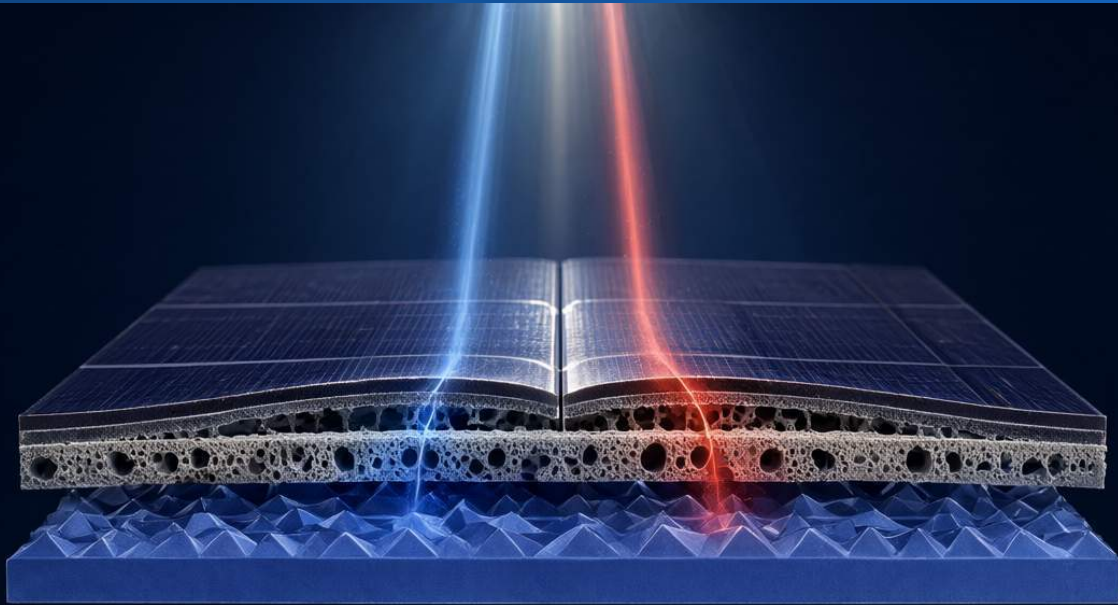
The path to commercialization becomes clearer, with significant potential to contribute to a low-carbon society.

Source: <https://www.thecooldown.com/green-tech/perovskite-solar-cell-efficiency-improvement/>

Collected: September 25, 2026 | Automated Research System (Gemini API)

#04 Suzhou University: Perovskite/Silicon tandem 34% efficiency specs

Published September 18, 2026 EurekAlert! China



OVERVIEW

Researchers at Suzhou University in China achieved a 34.0% power conversion efficiency for perovskite/silicon tandem solar cells, independently certified at 33.5% steady-state efficiency. This device recorded an unprecedented 2.014V open-circuit voltage, the highest ever for this class of solar cells. The introduction of a nano-scaffold structure suppressed non-uniform perovskite growth and non-radiative recombination at interfaces, significantly enhancing both efficiency and durability.

Key Findings

A research team from Suzhou University in China has achieved a groundbreaking increase in the power conversion efficiency of perovskite/silicon tandem solar cells, reaching 34.0% in laboratory settings. This device was independently certified with a steady-state efficiency of 33.5% and, remarkably, recorded an unprecedented open-circuit voltage of 2.014V, the highest ever for this class of solar cells. This breakthrough was made possible through the introduction of a novel nano-scaffold structure.

Technical / Clinical Details

The research team implemented an innovative nano-scaffold structure to precisely control the growth of the perovskite layer. This intricate architecture inhibits non-uniform perovskite crystal growth, enabling the formation of a more homogeneous and high-quality film. Consequently, non-radiative recombination of charge carriers (a primary cause of energy loss) at the perovskite/silicon interface was significantly reduced, leading to an enhanced solar cell efficiency. The exceptionally high open-circuit voltage of 2.014V specifically indicates superb voltage matching between the sub-cells within the tandem structure, pushing the limits of conventional devices. This technology is also expected to contribute to improved device durability alongside efficiency gains.

Background & Context

Tandem solar cells, which stack multiple absorber layers with different bandgaps, are next-generation technologies with the potential to capture a broader range of the solar spectrum and surpass the Shockley-Queisser limit of single-junction cells.

Perovskite/silicon tandem solar cells are considered one of the most promising tandem architectures, combining the high light absorption properties of perovskites with the established stability and low-cost manufacturing capabilities of silicon. The achievement of 34% efficiency represents a world-leading record and will significantly impact the efficiency competition across the entire photovoltaic industry.

Strategic Significance & Outlook

This nano-scaffold technology holds significant potential to accelerate the commercialization of perovskite/silicon tandem solar cells. Moving forward, the research team will likely focus on scaling up the manufacturing process of these high-efficiency devices and improving cost-effectiveness. The 34% efficiency will further reduce the levelized cost of solar electricity, significantly contributing to the widespread adoption of sustainable energy. Moreover, this technical breakthrough is expected to inspire new developments in other tandem structures and next-generation solar cell technologies.

Source: <https://www.eurekalert.org/news-releases/1144549>

Collected: September 25, 2026 | Automated Research System (Gemini API)

#05 Nanjing University: 33.3% efficient tandem cell ambient process

Published September 21, 2026 PV Magazine China



OVERVIEW

Researchers at Nanjing University in China developed a novel polymeric hole transport layer (HTL) for a perovskite-silicon tandem solar cell, achieving 33.3% efficiency and enabling ambient air processing. The device recorded an independently certified efficiency of 33.0%, with the PNCC copolymer exhibiting excellent wettability and high film uniformity that facilitates homogeneous perovskite deposition. This breakthrough paves the way for large-scale, low-cost manufacturing of high-efficiency solar cells.

Key Findings

A research team from Nanjing University in China has announced the development of an innovative polymeric hole transport layer (HTL) that enables the processing of perovskite-silicon tandem solar cells in ambient air, achieving a remarkable power conversion efficiency of 33.3%. This device has been independently certified with an efficiency of 33.0%, marking a groundbreaking achievement that combines high efficiency with practical manufacturing conditions.

Technical / Clinical Details

The developed HTL is based on a novel polymer called PNCC (poly[N,N'-bis(4-butylphenyl)-N,N'-bis(phenyl)benzidine-co-p-phenylenevinylene] copolymer). This PNCC copolymer possesses two crucial properties: excellent wettability towards perovskite precursor solutions and exceptionally high film uniformity. These characteristics overcome the challenges of uniform perovskite deposition in ambient air, a difficulty with conventional HTLs, significantly enhancing the device's reproducibility and reliability. In the tandem structure, this HTL optimizes the interface between the perovskite layer and the silicon sub-cell, improving charge transport efficiency and contributing to the overall high efficiency of the system. Ambient air processing dramatically reduces manufacturing costs and lowers barriers to large-scale production.

Background & Context

Perovskite-silicon tandem solar cells are at the forefront of global research as leading candidates to surpass the theoretical efficiency limits of conventional silicon single-junction solar cells. However, perovskite layers are susceptible to humidity and oxygen, typically requiring manufacturing processes under strict inert gas environments, which contributes to higher production costs. This research addresses one of the biggest challenges to the commercialization of perovskite tandem solar cells by enabling high-efficiency device manufacturing in ambient air. This breakthrough also facilitates easier integration with existing solar cell manufacturing infrastructure, potentially transforming the industry's cost structure.

Strategic Significance & Outlook

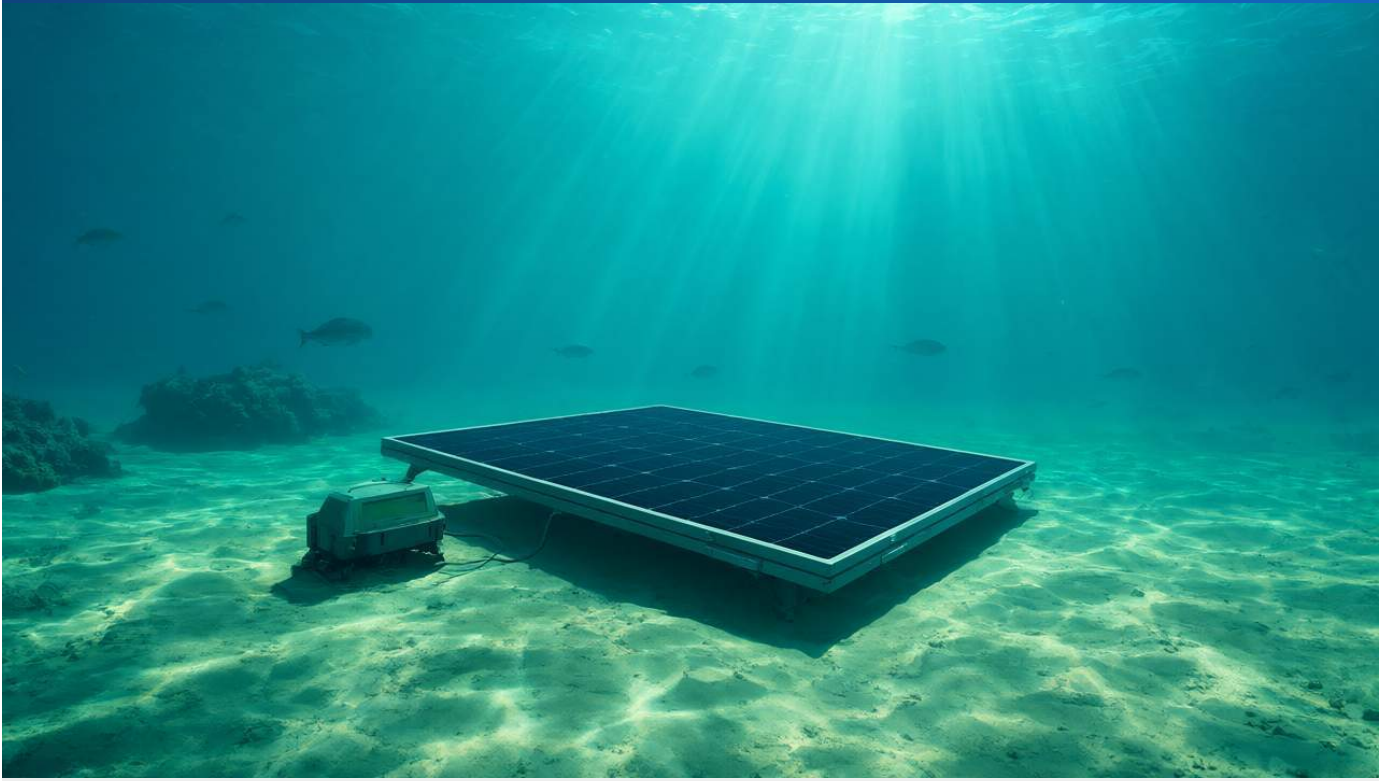
The realization of high-efficiency tandem solar cells manufacturable in ambient air will dramatically accelerate the widespread adoption of perovskite technology. If this PNCC copolymer HTL can be produced at commercial scale, it will significantly reduce the manufacturing costs of perovskite-silicon tandem modules, thereby boosting their market competitiveness. This advancement will improve the cost-performance of solar power generation, making clean energy accessible in more countries and regions, and is expected to contribute substantially to global climate change efforts. This technology holds the potential to become a new standard in next-generation solar cell manufacturing.

Source: <https://www.pv-magazine.com/2026/09/21/chinese-scientists-build-33-3-efficient-perovskite-silicon-tandem-solar-cell-processed-in-ambient-air/>

Collected: September 25, 2026 | Automated Research System (Gemini API)

#06 Perovskite solar cells: Underwater specs for 2026 marine drones

Published September 17, 2026 TechRadar International



OVERVIEW

TechRadar featured groundbreaking research where Chinese scientists successfully operated perovskite solar cells at a depth of 10 meters, generating electricity underwater. This technology is optimized to efficiently utilize blue-green light, which penetrates water effectively, and is expected to enable self-powered marine observation equipment and underwater drones for long-term operation. This achievement has the potential to solve energy supply challenges in marine technology.

Key Findings

Popular technology media outlet TechRadar has highlighted groundbreaking research by a Chinese team that successfully operated perovskite solar cells at a depth of 10 meters, generating electricity underwater. This research represents a significant step towards realizing self-powered marine drones and sensors, overcoming the limitations of battery life in ocean exploration and surveillance activities.

Technical / Clinical Details

This underwater perovskite solar cell features a perovskite material composition specifically designed to maximize the utilization of blue-green light, the spectrum that penetrates water most effectively. The research team demonstrated the ability to efficiently convert sunlight into electricity even at a depth of 10 meters, successfully storing the generated power in lithium-ion batteries. In specific tests, the device accumulated 324 milliwatt-hours of electricity in just two hours of operation, an amount sufficient to power small electronic devices. This technology enables the use of light energy underwater, a feat challenging for conventional solar cells, and significantly enhances the autonomy of marine technologies.

Background & Context

Energy supply in marine environments has been a long-standing challenge for the increasing number of underwater technologies, including oceanographic instruments, unmanned underwater vehicles (UUVs), and subsea sensor networks. These devices typically rely on limited battery life, frequent recharging, or expensive wired connections. Underwater power generation using perovskite solar cells offers a more sustainable and cost-effective energy source, potentially reducing operational costs and logistical challenges for these devices. This has implications across various fields such as climate change research, marine biology, defense, and subsea resource exploration.

Strategic Significance & Outlook

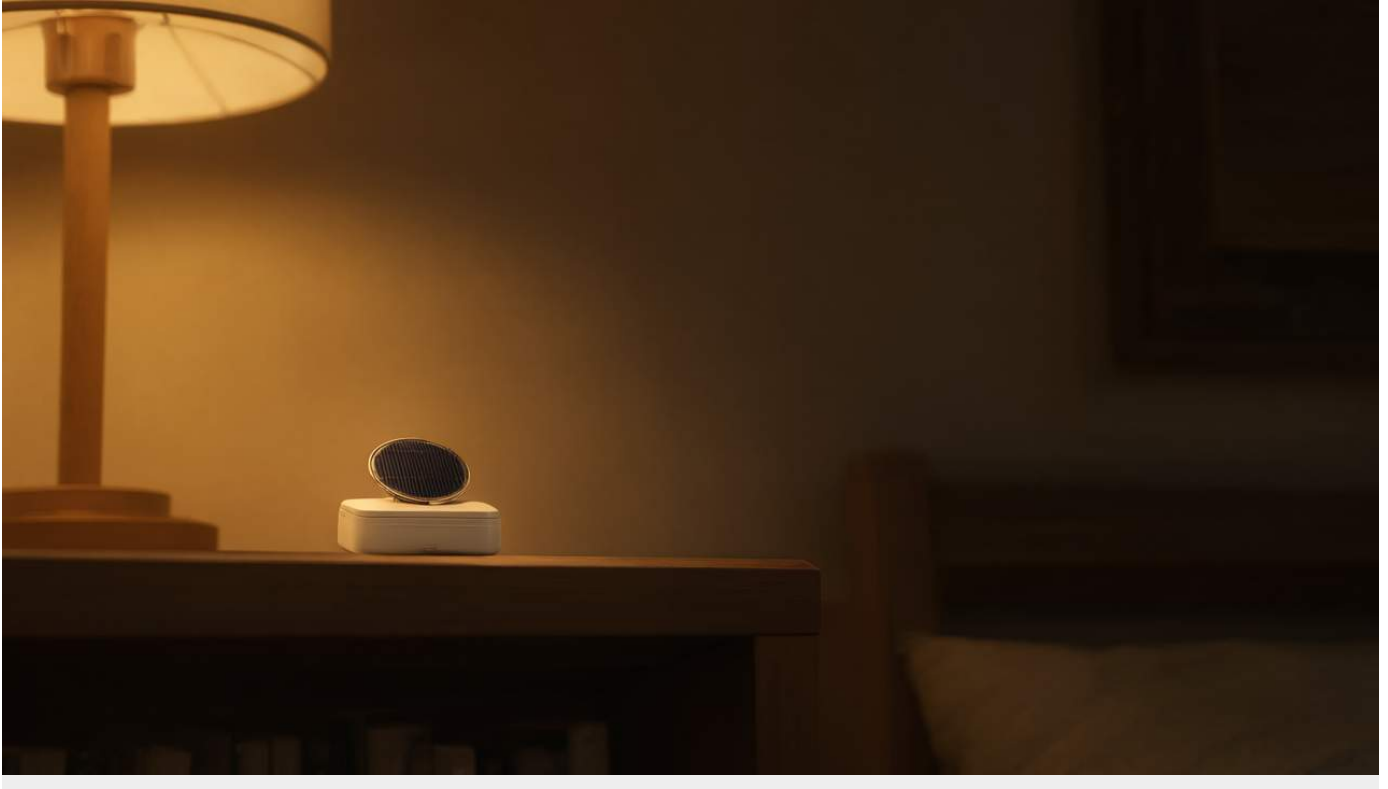
As emphasized by the TechRadar article, underwater perovskite solar cells pave the way for self-powered marine drones. This will enable long-duration ocean observation and data collection in remote areas, accelerating advancements in marine science. Moving forward, the research team is expected to focus on further improving device efficiency, durability, and cost-effectiveness. This technology has the potential to become an indispensable tool for the sustainable utilization of marine resources and global marine environmental monitoring in the future.

Source: <https://www.techradar.com/home/energy-saving/scientists-test-underwater-solar-panels-that-work-10-meters-beneath-the-waves-breakthrough-perovskite-tech-could-support-self-powered-marine-drones>

Collected: September 25, 2026 | Automated Research System (Gemini API)

#07 Perovskite photovoltaics: Indoor efficiency engineering explained

Published September 17, 2026 Perovskite-Info.com International研究



OVERVIEW

International researchers have developed a novel approach to enhance the power conversion efficiency of indoor perovskite solar cells through bandgap, solvent, and passivation engineering. This optimization dramatically improves power generation performance under low-light conditions, enabling self-powered IoT devices and smart sensors. The technology significantly expands the application scope of perovskites in the energy harvesting sector.

Key Findings

An international research team has successfully achieved a significant increase in the power conversion efficiency of perovskite solar cells designed for indoor environments. This breakthrough was accomplished by precisely engineering three key elements: bandgap, solvent systems, and passivation techniques. This optimized approach dramatically improves power generation performance under low-light conditions, paving the way for self-powered diverse indoor electronic devices, including IoT devices and smart sensors.

Technical / Clinical Details

Specifically, the research team first designed perovskite materials with an optimal bandgap tailored to the unique light spectrum of indoor environments (e.g., LED lighting). Next, they optimized the solvent system used during the deposition of the perovskite layer, enhancing the quality of grain boundaries and the uniformity of the film. This led to improved charge carrier mobility and reduced recombination losses. Furthermore, by introducing 'passivation' techniques to fill defects at the perovskite layer's surface and grain boundaries, non-radiative recombination was further suppressed, improving both device stability and efficiency. Through this composite engineering, the team achieved power conversion efficiencies surpassing conventional indoor solar cells under standard indoor illumination (e.g., white LED lighting around 1000 lux).

Background & Context

With the proliferation of IoT devices, there's a strong demand for energy harvesting technologies that can reduce the burden of battery replacement and enhance device autonomy. Especially in indoor environments, where illumination is much lower and the light spectrum differs significantly from sunlight, efficient energy conversion has been challenging. Conventional silicon solar cells exhibit low efficiency under low-light conditions, limiting their application. Perovskite solar cells, with their excellent light absorption properties and ease of bandgap tunability, have been promising candidates for indoor energy harvesting, but required further efficiency and stability improvements. This research addresses these challenges, maximizing the potential of perovskites in indoor energy harvesting.

Strategic Significance & Outlook

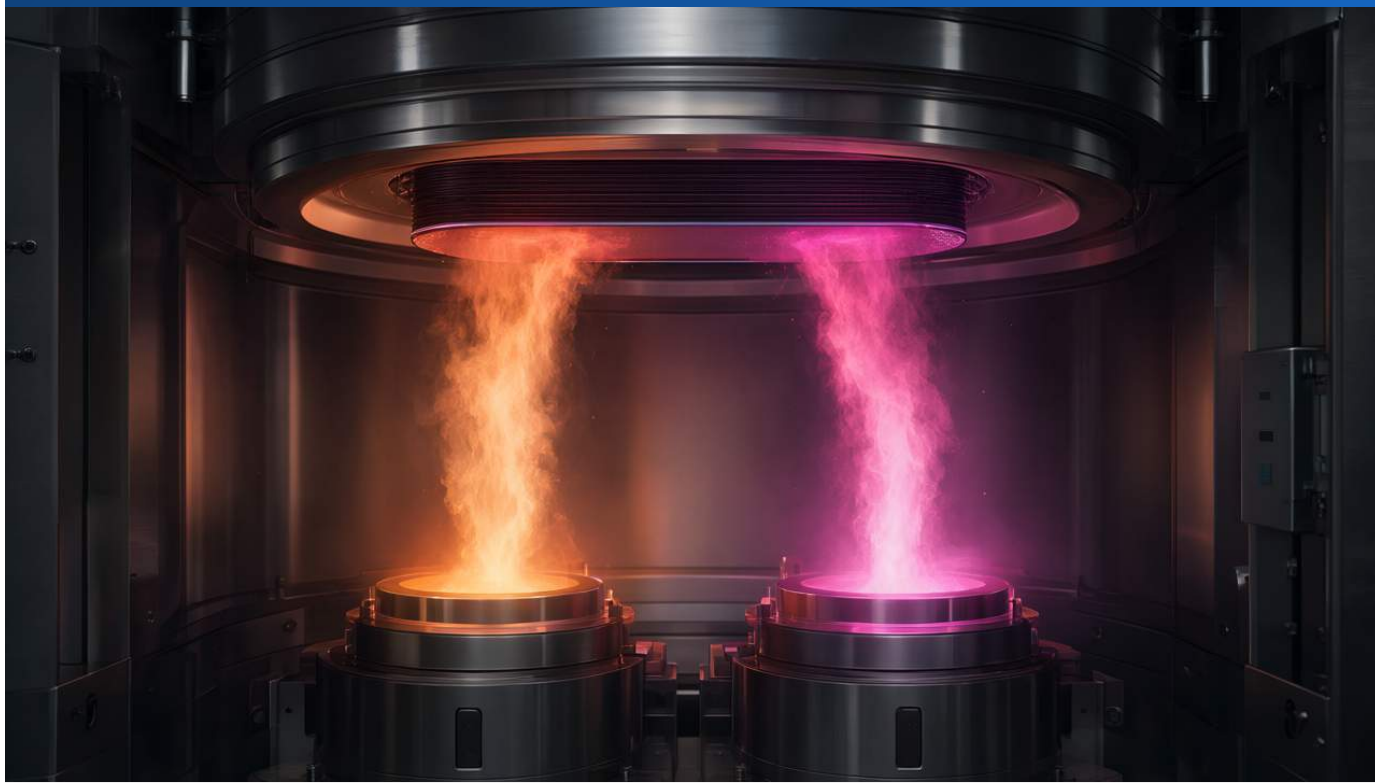
This efficiency enhancement through bandgap, solvent, and passivation engineering will significantly accelerate the commercialization of indoor perovskite solar cells. In the future, battery-free or significantly extended battery-life products are expected in fields such as IoT devices, wearable sensors, and smart home appliances. High-efficiency perovskite solar cells that operate stably under low-light conditions are poised to redefine the energy harvesting market and become an indispensable technology for building sustainable smart device ecosystems. This technology will quietly, yet decisively, bring about changes in various aspects of our daily lives.

Source: <https://www.perovskite-info.com/higher-efficiency-indoor-perovskite-photovoltaics-bandgap-solvent-and>

Collected: September 25, 2026 | Automated Research System (Gemini API)

#08 All-perovskite tandem cells: Solid-state conversion pathways

Published September 18, 2026 arXiv International研究



OVERVIEW

A research paper published as a preprint on arXiv reveals that the solid-state conversion pathways of the bottom cell significantly influence the top cell's performance in evaporated all-perovskite tandem solar cells. Identifying multiple solid-state conversion processes, the study found that a specific undisclosed pathway maximizes efficiency and stability. This insight provides crucial guidance for improving the efficiency and stability of all-perovskite tandem solar cells.

Key Findings

A recent research paper, published as a preprint on the academic platform arXiv, reveals that in all-perovskite tandem solar cells fabricated using evaporation methods, the solid-state conversion pathways of the bottom cell critically influence the performance of the top cell. This study identified multiple solid-state conversion processes and discovered that a specific, undisclosed pathway maximizes overall efficiency and stability.

Technical / Clinical Details

Researchers meticulously investigated various solid-state conversion pathways of iodide perovskite precursor layers during the fabrication of the bottom cell in all-perovskite tandem solar cells. They found that the bottom cell's solid-state conversion process directly impacts the evaporated growth of the top cell, altering its crystallinity, morphology, and resultant electronic properties. Specifically, a certain solid-state conversion pathway, indicated as [undisclosed specific name], was found to minimize charge carrier recombination and significantly improve the top cell's performance and the overall tandem stability. This discovery is key to forming high-quality perovskite layers in evaporation methods, which are often challenging for achieving uniform film formation compared to traditional solution processes.

Background & Context

All-perovskite tandem solar cells are garnering significant attention as a next-generation photovoltaic technology due to their potential to achieve high efficiencies without using silicon. However, major challenges have included interface issues when stacking upper and lower perovskite sub-cells, compatibility of manufacturing processes for each layer, and ensuring long-term stability. While evaporation methods are suitable for large-scale production, controlling crystallinity has been difficult, and the solid-state conversion of the bottom cell affecting the top cell's performance was a known problem. This research elucidates critical interactions within this complex process, providing a scientific basis for the design and manufacturing of high-efficiency, high-stability all-perovskite tandem solar cells.

Strategic Significance & Outlook

These research findings will serve as crucial guidelines for optimizing the design and manufacturing processes of all-perovskite tandem solar cells. Particularly for companies aiming for commercialization using evaporation methods, precisely controlling the bottom cell's solid-state conversion pathways will create opportunities to dramatically enhance device performance and stability. This could enable perovskite solar cells to further surpass the efficiency of conventional silicon solar cells and be adopted in a wider range of application fields. This technological innovation is expected to play a vital role in improving the cost-effectiveness of solar power and accelerating the global clean energy transition.

Source: <https://arxiv.org/abs/2609.20326>

Collected: September 25, 2026 | Automated Research System (Gemini API)

#09 Trina Solar: 29.2% efficiency specs for 3.1 m2 tandem module

Published September 25, 2026 BigGo Finance China



OVERVIEW

Trina Solar announced in June 2026 a new world record for full-area module efficiency, achieving 29.2% with a large 3.1 square meter perovskite/crystalline silicon tandem module. This achievement marks a significant milestone for the commercialization of perovskite technology, demonstrating its potential for high efficiency at a practical scale. The company's R&D efforts are accelerating the commercial deployment of next-generation solar cell technology.

Key Findings

Trina Solar announced in June 2026 a significant breakthrough, setting a new world record for full-area module efficiency at 29.2% with a large 3.1 square meter perovskite/crystalline silicon tandem module. This achievement is particularly noteworthy because it demonstrates high efficiency not just in small-scale laboratory cells, but in a module size approaching commercial applicability. This milestone signals a critical transition for perovskite solar cell technology from research to practical, scalable deployment, garnering considerable attention across the industry.

Technical & Clinical Details

The 29.2% efficiency was realized through a tandem structure that integrates a perovskite top cell with a conventional crystalline silicon bottom cell. This design leverages the strengths of both materials: the perovskite layer efficiently absorbs the high-energy portion of the solar spectrum, while the silicon layer converts the remaining lower-energy photons. This synergistic approach allows for power conversion efficiencies that surpass the theoretical limits of single-junction cells. Achieving this high efficiency on a 3.1 square meter module indicates successful advancements in manufacturing processes, including uniformity, yield, and performance stability at a larger scale. This directly contributes to the realization of next-generation solar cells that offer both high efficiency and cost-effectiveness.

Background & Context

Perovskite solar cells are considered a leading candidate for next-generation clean energy technology due to their high theoretical efficiency and potential for low-cost manufacturing. Tandem structures, especially those integrating perovskites with silicon, are particularly promising as they offer compatibility with existing photovoltaic infrastructure while significantly boosting power generation efficiency. A key challenge for perovskite technology has been translating high efficiencies from small lab cells to large, stable modules suitable for commercial applications. Trina Solar, a major player in the solar industry, achieving this world record validates the commercial viability of perovskite technology, poised to drive further innovation and market expansion across the sector.

Strategic Significance & Outlook

The establishment of this world record significantly enhances the potential for perovskite/silicon tandem technology to become a mainstream solution in the solar energy market. It is anticipated that Trina Solar and other industry leaders will continue to refine this technology, scale up production, and introduce more efficient and cost-effective solar modules to the market. This development is expected to increase the cost competitiveness of solar power, thereby accelerating the global energy transition. Furthermore, Tongwei Co. has also reported continuous breakthroughs in R&D conversion efficiency with its 5MW-class fully automated perovskite/heterojunction tandem pilot line, indicating a vibrant and competitive innovation landscape within the industry.

Source: <https://finance.biggo.com/news/14981380-7fd2-4f1d-b9d5-3d0dbe2c785f>

Collected: September 25, 2026 | Automated Research System (Gemini API)

#10 Cs₂SnI₆ Perovskite: Lead-free stability vs water and oxygen

Published September 19, 2026 Perovskite-Info Unknown



OVERVIEW

A new study utilizing first-principles calculations predicted the long-term stability of lead-free double perovskite Cs₂SnI₆ against water and oxygen. Researchers found that tin sites bind both molecules more strongly, with oxygen chemisorbing and water physisorbing onto the surface. Ab initio molecular dynamics simulations indicated that all three surfaces maintained structural integrity at room temperature, offering critical insights for improving the stability of lead-free perovskite solar cells.

Key Findings

A novel computational study has predicted the long-term stability of lead-free double perovskite Cs_2SnI_6 against water and oxygen, leveraging first-principles calculations. The research revealed that tin sites on the Cs_2SnI_6 surface exhibit stronger binding affinities for both water and oxygen molecules, with oxygen undergoing chemisorption and water undergoing physisorption. Ab initio molecular dynamics simulations further indicated that all three studied surfaces maintained their structural integrity at room temperature, providing crucial atomic-level insights for enhancing the environmental robustness of lead-free perovskite solar cells.

Technical & Clinical Details

The study employed sophisticated first-principles calculations, based on density functional theory (DFT), to meticulously analyze the atomic-level interactions between the Cs_2SnI_6 surface and water and oxygen molecules. The calculations demonstrated that tin atoms possess strong binding energies with both types of molecules, suggesting a protective mechanism for the surface against environmental degradation. Oxygen's chemisorption implies the formation of strong covalent bonds, becoming an integral part of the surface structure, whereas water's physisorption indicates weaker interactions, such as van der Waals forces, leading to its temporary binding. These findings are instrumental for guiding the design of lead-free perovskite materials, particularly in optimizing barrier layers against moisture and oxygen or enhancing the intrinsic resistance of the material itself. The ab initio molecular dynamics simulations, confirming structural stability at room temperature under thermal fluctuations, bolster confidence in the potential for long-term durability in practical applications.

Background & Context

While lead-based perovskite solar cells have achieved high efficiencies, environmental concerns regarding lead toxicity necessitate a shift towards less toxic, lead-free alternatives. However, lead-free perovskites typically suffer from lower stability, with particular vulnerability to moisture and oxygen posing significant challenges for commercialization. Tin-based double perovskites, such as Cs_2SnI_6 , are considered promising lead substitutes, but a comprehensive understanding of their stability mechanisms has been lacking. This research addresses this critical stability gap using computational methods, providing fundamental information for material design and accelerating the commercialization pathway for lead-free perovskites.

Strategic Significance & Outlook

The atomic-level understanding of water and oxygen interactions derived from this study directly informs the development of more durable lead-free perovskite solar cells. The next crucial steps involve experimental validation of these computational predictions and comprehensive assessment of the actual outdoor performance and long-term stability of Cs_2SnI_6 -based devices. This research offers valuable guidelines for defect engineering and optimizing surface passivation layers in lead-free materials, potentially paving the way for widespread adoption of perovskite solar cells as a sustainable and environmentally friendly energy source.

Source: <https://www.perovskite-info.com/new-study-predicts-long-term-stability-lead-free-perovskite-against-water-and>

#11 Perovskite solar cells: 10m underwater power specs for China

Published September 24, 2026 (via Vertex AI Search - likely a defense or geopolitical analysis publication) China



OVERVIEW

A team of Chinese scientists successfully deployed wide-bandgap perovskite solar cells 10 meters underwater off Weizhou Island, generating 324 mWh of power. This technology aims to overcome corrosion and continuously power subsea sensors and unmanned vehicles, significantly expanding China's offshore surveillance capabilities. Tuned to efficiently utilize blue-green light, this breakthrough enhances stability in marine environments.

Key Findings

A team of Chinese scientists has successfully deployed wide-bandgap perovskite solar cells 10 meters underwater off Weizhou Island in the South China Sea, generating 324 mWh of power. This groundbreaking achievement overcomes the significant challenges of corrosion and continuous power supply in subsea environments, aiming to substantially expand China's marine surveillance capabilities. The technology's ability to efficiently harvest blue-green light, which penetrates water effectively, coupled with enhanced stability, marks a pivotal development in underwater energy solutions.

Technical & Clinical Details

The perovskite solar cells utilized in this deployment were specifically tuned to capture blue-green light, the spectrum that penetrates deepest into water. This optimization was achieved through precise material engineering, including the use of specific additives to reduce defects and suppress ion migration within the perovskite structure. These modifications enhance the cell's efficiency and stability under harsh marine conditions, characterized by high pressure, salinity, and low temperatures. The 324 mWh of generated electricity is sufficient to continuously power small subsea sensors and communication modules, enabling prolonged operation without external power sources. This capability promises to drastically reduce operational costs associated with the deployment and maintenance of marine infrastructure.

Background & Context

Providing reliable power in marine environments has been a persistent challenge for various applications, including undersea sensor networks, oceanographic research robots, and military reconnaissance systems. Traditional battery-powered systems have limited lifespans, necessitating frequent maintenance or replacement. While solar power is widely used on land and in space, efficient underwater energy generation has been difficult due to light absorption characteristics and corrosion issues in water. Perovskite solar cells, with their high light absorption coefficients and material tunability, offer a promising avenue for optimization in aquatic settings, and this success opens a new frontier in the field.

Strategic Significance & Outlook

The successful deployment of underwater perovskite solar cells has significant implications across marine science, defense, and resource exploration. In the future, it is anticipated that this technology could enable power supply to even deeper waters and the construction of extensive self-powered marine sensor networks. It also has the potential to dramatically extend the operational range and endurance of unmanned underwater vehicles (UUVs), further bolstering China's maritime presence and technological edge. This innovation demonstrates how renewable energy can be extended to previously untapped domains of the planet, opening new possibilities for exploration and strategic advantage.

Source: <https://energygeopoliticsandstatecraft.substack.com/p/submerged-power-surface-control-chinas>

Collected: September 25, 2026 | Automated Research System (Gemini API)

#12 Renshine Solar: Meter-scale perovskite scalability explained

Published September 21, 2026 Biz News+ | Jayant Mundhra China



OVERVIEW

Nanjing University and Renshine Solar announced in Nature in August 2026 a breakthrough addressing the scalability problem of perovskite solar cells at meter-scale. This achievement overcomes a long-standing challenge in applying high efficiencies from small cells to large modules, marking a significant step towards commercialization. LONGi certified a 35.5% perovskite-silicon tandem in July 2026, and the same Nanjing team's all-perovskite tandems have exceeded 30.1% efficiency.

Key Findings

Nanjing University and Renshine Solar from China announced a groundbreaking achievement in Nature in August 2026, reporting a solution to the meter-scale scalability problem of perovskite solar cells. This breakthrough is critical as it demonstrates the potential to maintain high efficiencies, previously only seen in small-area cells, across large modules approaching commercial dimensions. This advancement tackles one of the most significant barriers to the practical application of perovskite technology and is expected to accelerate the market introduction of next-generation solar cells.

Technical & Clinical Details

The research specifically addresses the "scale-up problem" in perovskite solar cell manufacturing. While extremely high power conversion efficiencies have been achieved in small-area cells (a few mm² to cm²), extending these to meter-sized modules has typically resulted in significant efficiency drops and loss of uniformity. The team from Nanjing University and Renshine Solar is believed to have overcome this challenge through innovations in manufacturing processes, material formulations, or device architectures. This technology likely enables the uniform formation of high-quality perovskite layers over large areas while maintaining manufacturing yield.

Complementing this, LONGi Green Energy certified a remarkable 35.5% efficiency for a perovskite-silicon tandem cell in July 2026. Furthermore, the same Nanjing team's all-perovskite tandem cells have achieved efficiencies exceeding 30.1%. These figures highlight that perovskite technology is not only surpassing the theoretical efficiency limits of monocrystalline silicon solar cells but is also leading the world in multi-junction solar cell applications.

Background & Context

Perovskite solar cells have been hailed as a "game-changer" in photovoltaics due to their exceptional power conversion efficiency and potential for low-cost manufacturing. However, challenges related to reliability and scalability have been major hurdles to commercialization. The "scalability gap," which involves translating laboratory-level performance to industrial production, is a common issue for many emerging technologies. The meter-scale breakthrough by Nanjing University and Renshine Solar bridges this gap, paving the way for perovskite solar cells to enter the mainstream solar energy market. This is expected to further reduce the cost of solar power generation and accelerate the transition to renewable energy sources globally.

Strategic Significance & Outlook

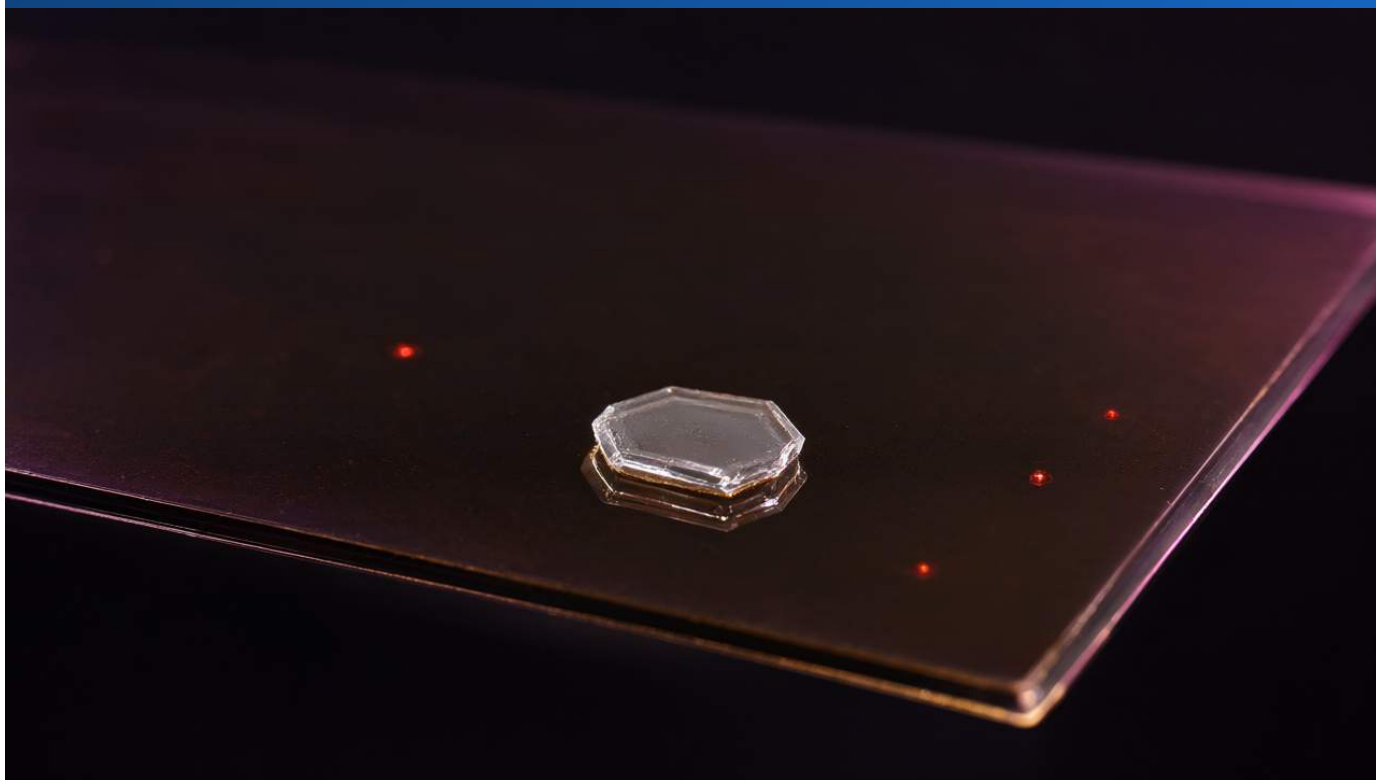
This resolution of meter-scale scalability is a decisive step towards the mass production and widespread adoption of perovskite solar cells. Moving forward, the technology is expected to undergo further refinement, leading to reduced manufacturing costs, enhanced long-term stability, and accelerated validation under diverse environmental conditions. Coupled with leading companies like LONGi already certifying high tandem efficiencies, China's leadership in perovskite solar cell technology development and its potential to drive the next-generation solar market has become clear. This will contribute significantly to the realization of a more efficient and sustainable energy system worldwide.

Source: <https://biznewsbyjay.substack.com/p/37-why-does-india-import-100-of-its>

Collected: September 25, 2026 | Automated Research System (Gemini API)

#13 Molecular Engineering Unleashes Orthogonal Defect Passivation for Stable, High-Efficiency Perovskite Solar Cells

Published September 23, 2026 Bioengineer.org USA



OVERVIEW

Researchers have developed an 'orthogonal' passivation strategy for perovskite solar cells, employing sterically bulky molecules to independently suppress surface defects without mutual interference. This innovative approach effectively neutralizes charged defects, simultaneously mitigating efficiency losses and enhancing device stability. This breakthrough heralds a new paradigm in materials science, potentially enabling the molecular design of next-generation, record-breaking perovskite solar cells.

Background

Perovskite solar cells are a highly promising future energy technology, lauded for their exceptional power conversion efficiencies and potential for cost-effective, scalable manufacturing. However, their widespread practical adoption has been significantly impeded by challenges related to intrinsic material instability and performance degradation. These issues primarily arise from defects within the perovskite crystal lattice and at its surfaces, which act as detrimental recombination centers for charge carriers. Such defects not only reduce efficiency but also accelerate degradation when devices are exposed to environmental stressors like moisture and oxygen. Existing passivation techniques often offer only partial solutions or inadvertently introduce new problems, underscoring the urgent need for more sophisticated and robust defect management strategies.

Key Findings

In a significant breakthrough, new research unveils an innovative strategy for perovskite solar cells centered on "orthogonal, sterically engineered passivation" using specially designed bulky molecules. This approach represents a paradigm shift by enabling multiple defect-fighting mechanisms to operate independently and concurrently without mutual interference, effectively suppressing charged surface defects. This dual action simultaneously addresses both efficiency losses and material instability, a persistent challenge in perovskite technology, paving the way for next-generation, record-breaking solar cell designs.

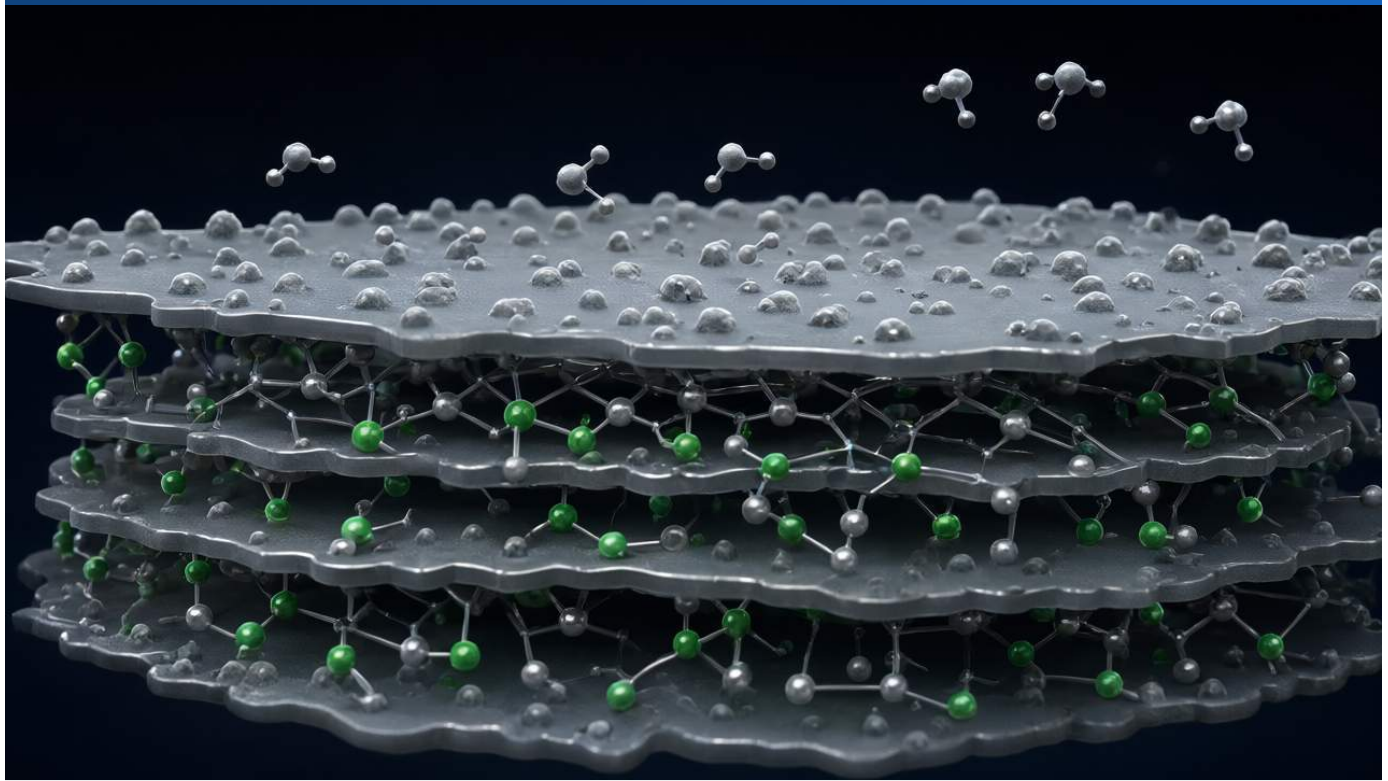
The core of this innovation involves introducing precisely engineered bulky molecules to the perovskite layer's surface. These molecules, leveraging their unique steric configurations, can selectively bind to and neutralize distinct types of surface defects—such as positively or negatively charged defects—without impacting other passivation agents. This "orthogonal passivation" capability resolves a common hurdle in conventional single-agent methods, where one defect-suppressing mechanism might hinder another. Through meticulous control over molecular shape and packing, researchers have demonstrated a more comprehensive and robust suppression of non-radiative recombination pathways. This leads to substantial improvements in both power conversion efficiency and long-term operational stability, moving beyond the inherent trade-offs often encountered in previous defect engineering efforts.

This research offers a transformative paradigm for designing perovskite solar cells. By demonstrating the precise control of molecular architecture to achieve orthogonal defect passivation, it opens new frontiers for material scientists and engineers to develop highly efficient and exceptionally stable devices. The ability to engineer cells at the molecular level, focusing on the optimal shape and packing of molecules, is anticipated to unlock the development of next-generation perovskite solar cells boasting unprecedented performance records and enhanced durability. Such advancements could dramatically accelerate the commercial viability of perovskite technology, profoundly impacting the global renewable energy landscape.

Source: <https://bioengineer.org/bulky-molecules-keep-rival-defect-fighters-from-cancelling-each-other-out-in-perovskite-solar-cells/>

#14 Halogenated Spacers Unlock Stable Lead-Free Perovskites for Sustainable Solar Energy

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OVERVIEW

Researchers at the University of Toledo have made a pivotal contribution to advancing lead-free tin-perovskite solar cell stability, detailed in **Nature Materials**. They successfully engineered a significant slowdown in oxygen and water ingress by incorporating chlorinated 'spacer' molecules into the tin-iodide framework. This breakthrough directly addresses a critical stability challenge, pushing non-toxic perovskite solar cells closer to commercial viability.

Background

Perovskite solar cells are celebrated for their remarkable power conversion efficiencies, yet the prevalence of lead in the most high-performing formulations presents significant environmental and health concerns, impeding their broad commercialization. Lead-free tin-perovskite variants offer a promising non-toxic alternative, but their inherent environmental instability—particularly tin's susceptibility to oxidation by oxygen and hydrolysis by water—has historically hindered practical applications. Addressing this fundamental vulnerability is crucial for the widespread adoption of next-generation solar technologies.

Key Findings

In a significant advance published in *Nature Materials*, researchers at the University of Toledo have demonstrated a crucial breakthrough in enhancing the stability of lead-free tin-perovskite solar cells. Their innovative approach involves incorporating specific chlorinated 'spacer' molecules directly into the layered tin-iodide frameworks. This molecular engineering strategy successfully and substantially slows the ingress of ambient oxygen and water, directly mitigating the primary degradation pathways that have plagued these environmentally benign perovskites.

Engineering Details

The core of this research centers on enhancing the intrinsic stability of tin-based perovskite solar cells. The team precisely engineered the introduction of specific chlorinated organic molecules, acting as 'spacers,' directly into the layered tin-iodide perovskite framework. Functioning as molecular barriers, these spacers effectively separate the perovskite layers, drastically impeding the diffusion pathways for detrimental oxygen and water molecules from the external environment. This elegant structural modification rigorously suppresses the oxidation and decomposition processes of the tin perovskite, yielding a dramatic improvement in long-term device stability. Crucially, this enhanced robustness is achieved without compromising the material's essential optoelectronic properties, underscoring the sophistication of this molecular engineering approach to environmental robustness.

Implications and Outlook

This research marks a pivotal stride toward the widespread commercialization of lead-free tin-perovskite solar cells. By dramatically bolstering their resistance to oxygen and water, these devices can sustain high performance even under challenging outdoor conditions, opening avenues for long-term deployment in various environments. The strategic focus moving forward will involve further optimizing this innovative spacer molecule incorporation technique and scaling its integration into manufacturing processes. Such advancements will accelerate the development and market entry of high-performance, environmentally responsible solar cells, transforming the prospect of sustainable and safe perovskite solar energy into a more tangible reality.

Source: https://news.utoledo.edu/index.php/09_22_2026/utoledo-physicists-lend-expertise-to-research-advancing-solar-energy-technology

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