Tandem Solar Cell: Affordable and Accessible!

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ART-PV india

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Industry Partners

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Content

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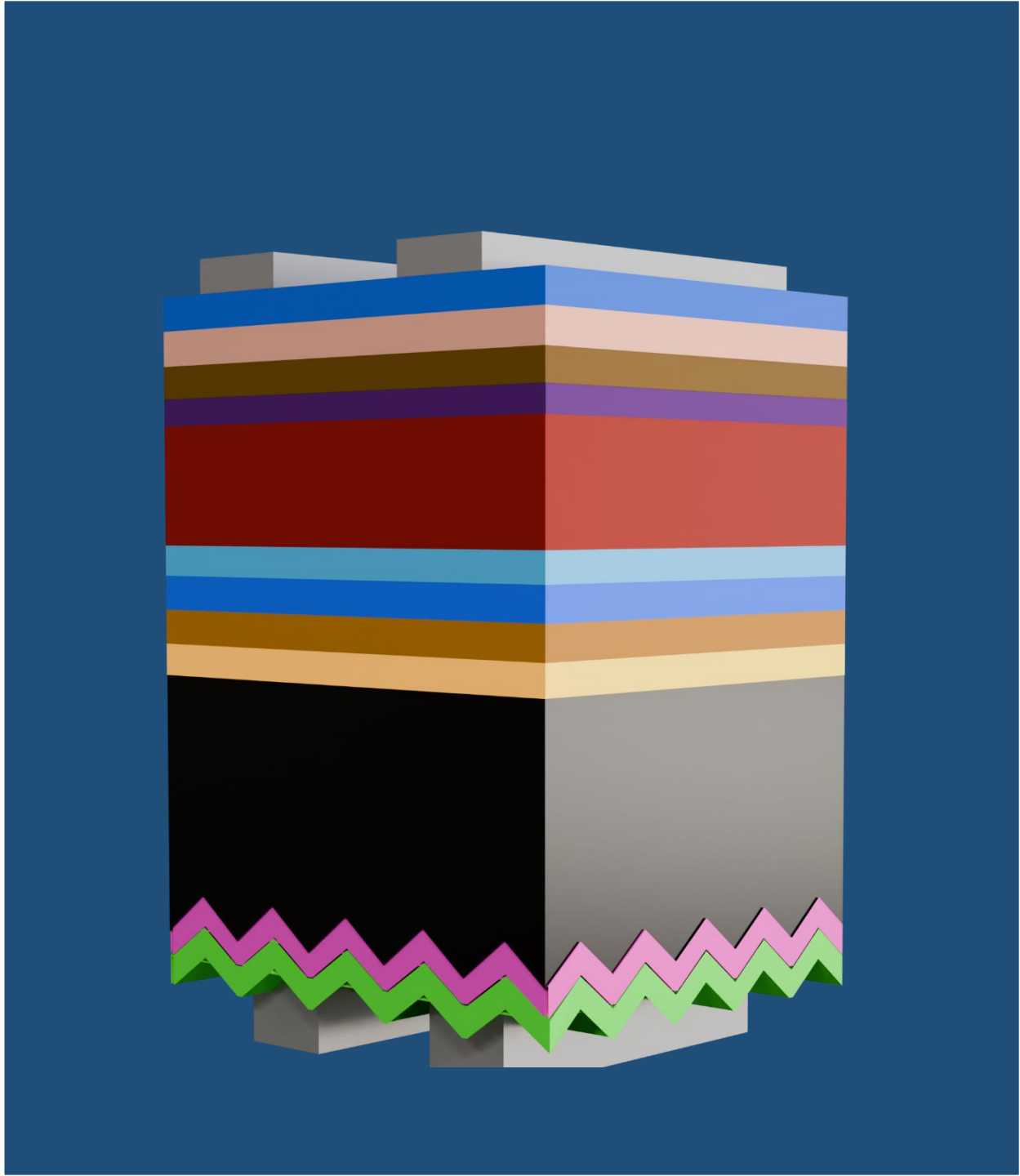
Solar cell and module market overview

Why ART PV India

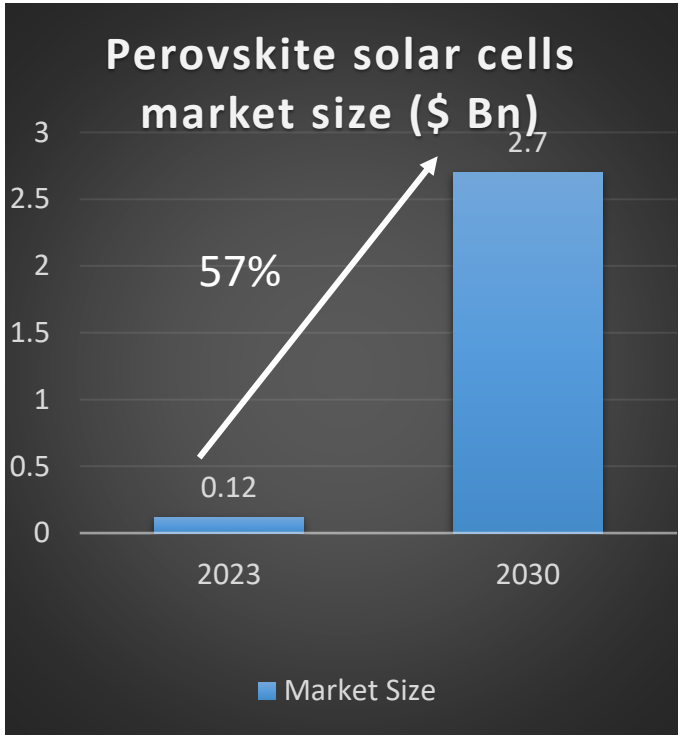
Product development roadmap

Business model

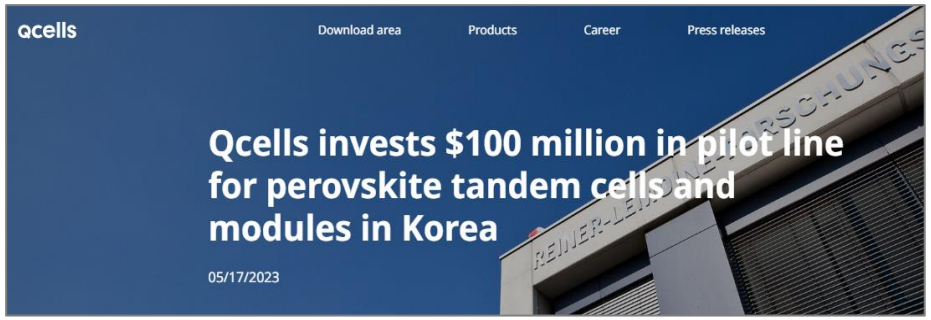


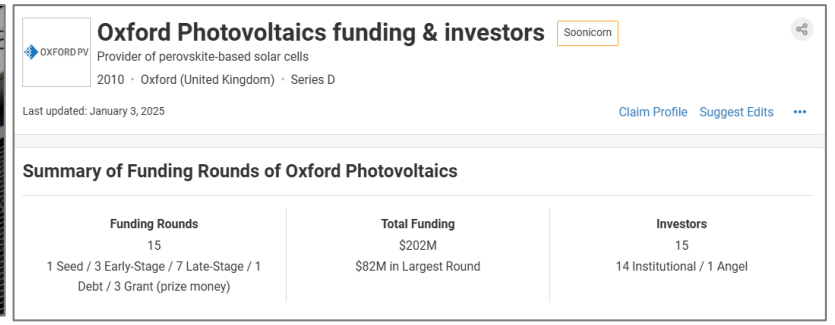
…. there is huge growth projected for perovskite cells with 57% CAGR between 2024-31 with all global giants investing significantly in perovskite technology

Projected Perovskite cell market size



Major investments in Perovskite technology





Source: Fortune Business Insights (link)

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Trina Solar Unveils World's First 800W+ Tandem Module, Ushering In A New Era Of Solar Power

By **S.S. Dev** - 30th March 2025 · 6561 · 0

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Representational image. Credit: Canva

Trinasolar, a global leader in smart photovoltaic (PV) and energy storage solutions, has set a new industry benchmark by developing the world's first industrial-standard solar PV module capable of delivering over 800W of maximum power. The 3.1m² module, built with advanced 210mm × 105mm perovskite/silicon tandem solar cells, has achieved a peak

Home » China's GCL to invest USD$98 million in tandem silicon/perovskite PV

China's GCL to invest USD$98 million in tandem silicon/perovskite PV

PCE ~ 26.3% August 2024

GCL Technology, one of China's largest solar panel materials producers, will reported illion yuan (almost USD$98 million) to transition to a more lucrative next-generation technolo ople with losses and oversupply.

The Hong Kong-listed company aims to complete the first phase of a 500 m the middle of next year, for solar modules that combine cells stacked w according to a statement by Fan Bin, chairman of GCL Perovskite. " technology lies in the ample room for uplifting its energy conversio manufacturers are willing to invest in its development." The future cost of silicon technology could be lower than the crystalline silicon technology, he added.

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34.6%! Record-breaker LONGi Once Again Sets a New World Efficiency for Silicon-perovskite Tandem Solar Cells

Global News 2024.6.18

OXFORD PV

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Oxford PV and Trinasolar announce a landmark Perovskite PV patent licensing agreement

Wednesday, 9 April 2025

qcells

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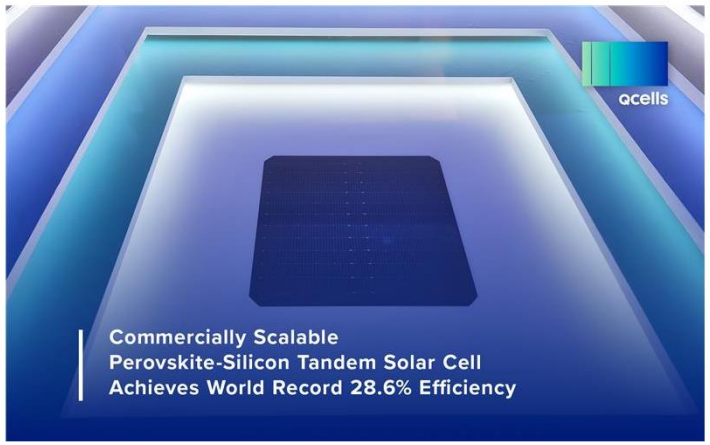


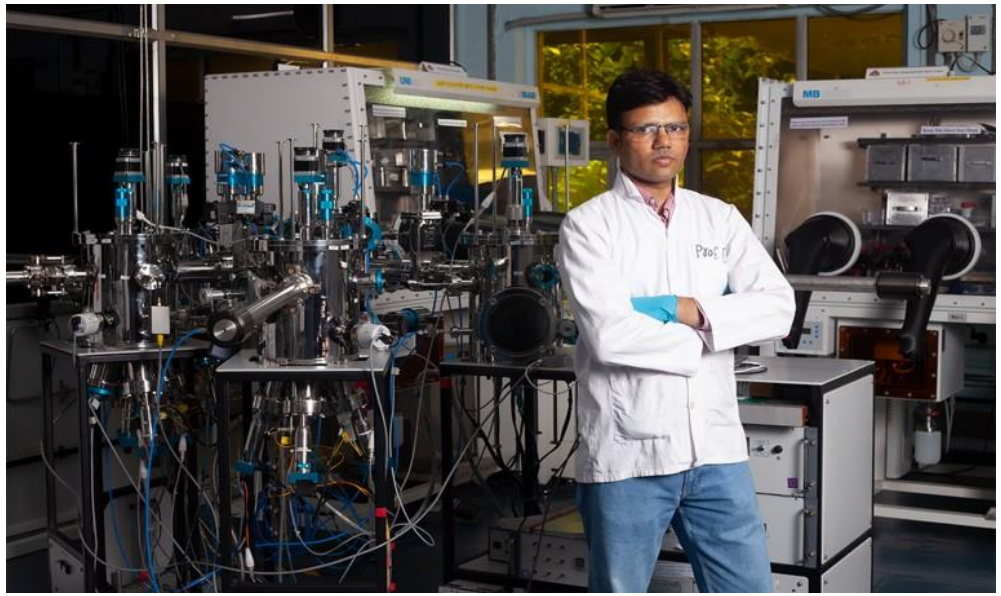
Qcells Achieves World Record Efficiency for Commercially Scalable Perovskite-Silicon Tandem Solar Cell

9. We have been recognized by Nature magazine for next generation of solar cells and have been published in leading global newsletters

nature

Unconventional materials that do more with light

Dinesh Kabra is working with the next generation of optoelectronic materials for solar cells and display technologies.



Media platform	Description	Link
pv magazine June 2024	Perovskite-cadmium telluride tandem solar cell based on special electrode achieves 24.2% efficiency	Link
ACS Publications Most Trusted. Most Cited. Most Read. April 2024	Perovskite Solar Cells Dominated by Bimolecular Recombination–How Far Is the Radiative Limit?	Link
ACS Publications Most Trusted. Most Cited. Most Read. May 2024	4-T CdTe/Perovskite Thin Film Tandem Solar Cells with Efficiency >24%,	Link
pv magazine May 2023	4T silicon-erovskite PV cell hits 26.03% efficiency with transparent contact	Link
pv magazine Sept 2023	Inverted perovskite solar cell based on methyl-substituted carbazole HTL achieves 20.1% efficiency	Link
ACS Publications Most Trusted. Most Cited. Most Read. Aug 2023	Resolving the Hydrophobicity of the Me-4PACz Hole Transport Layer for Inverted Perovskite Solar Cells with Efficiency >20%	Link
RRL Solar April 2023	Stable and Efficient Large-Area 4T Si/perovskite Tandem Photovoltaics with Sputtered Transparent Contact	Link

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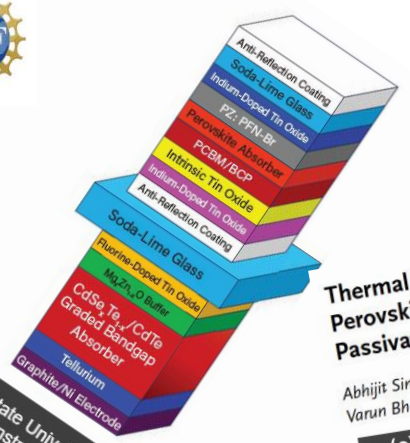
CATALYZING COMMERCIALIZATION

CdTe-Perovskite Tandem Photovoltaics Achieve Record Efficiency

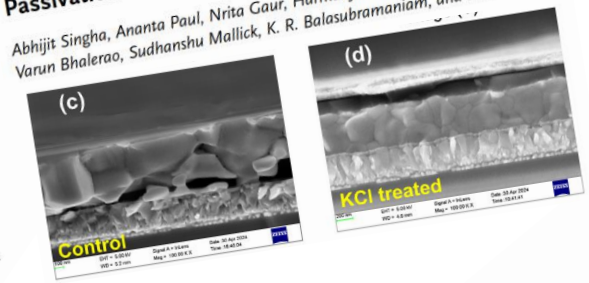
Achieving energy sustainability necessitates efficient, cost-effective renewable energy solutions such as photovoltaics, which convert solar energy to electricity. A growing share of commercial solar cells are made with polycrystalline cadmium telluride (CdTe) thin-film technology. CdTe solar cells of at least 1 cm^2 have demonstrated up to



Researchers at Colorado State Univ. in collaboration with Indian Institute of Technology Bombay demonstrated 24.2% efficiency for a four-terminal two-junction CdTe-perovskite tandem solar cell. Perovskite and $CdSe_xTe_{1-x}$/CdTe layers absorb the light to generate electrical charge while other layers facilitate extraction of electricity and the glass substrate provides structural resilience.

Thermal Stress Mitigation and Improved Performance in Perovskite Solar Cells *via* Lattice Matched Alkali Halide Passivation

Abhijit Singha, Ananta Paul, Nrita Gaur, Harmanjeet Singh Bilkhu, Anuraag Arya, Varun Bhalerao, Sudhanshu Mallick, K. R. Balasubramaniam, and Dinesh Kabra*



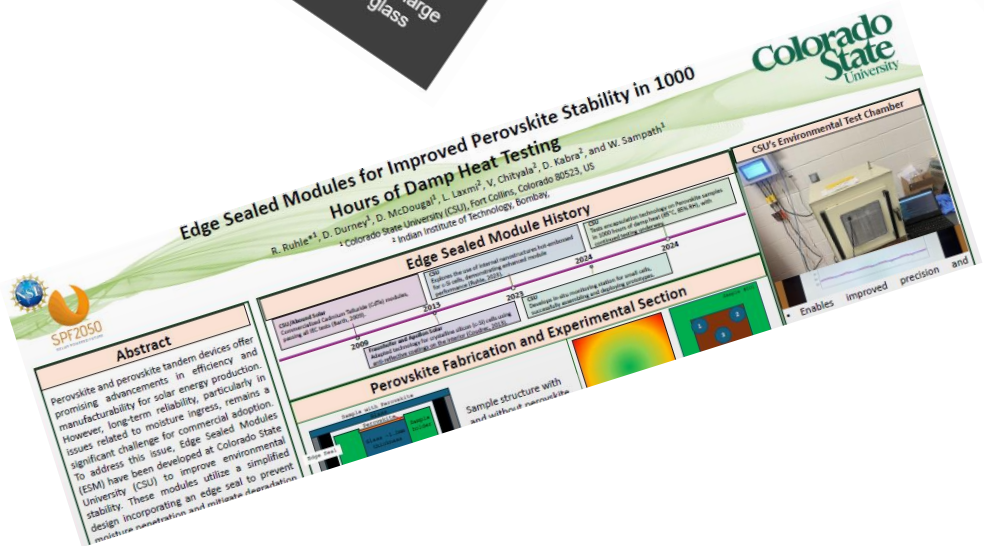
Novel Module Architecture for Improved Stability of Perovskites in 1000 Hour Damp Heat Test

Ryan Ruhle,[1] David Durney,[1] Larry Maple,[1] Laxmi Laxmi,[2] Venkatesh Chityala,[2] Dinesh Kabra,[2] and Walajabad Sampath,[1]

[1] Colorado State University (CSU), Fort Collins, Colorado 80523, US

[2] Indian Institute of Technology Bombay (IITB), Powai, Mumbai 400076, India

Abstract— Photovoltaic (PV) energy is the fastest-growing form of energy production globally, and advancements in module design are critical to sustaining this growth. The Edge Sealed Module (ESM) architecture eliminates the vacuum lamination processes which require high temperatures and pressures. Internal space can incorporate moisture-linked encapsulants, significantly reducing the need for absorbing desiccants, offering a more effective solution than traditional encapsulants for capturing moisture which breaks through. These features enable rapid prototyping for a variety while improving reliability and



THE ECONOMIC TIMES | Industry

English Edition | Today's ePaper

IIT Bombay achieves major breakthrough in solar tech

By Krishna Kumar, ET Bureau | Last Updated: Mar 18, 2025, 11:33:00 AM IST

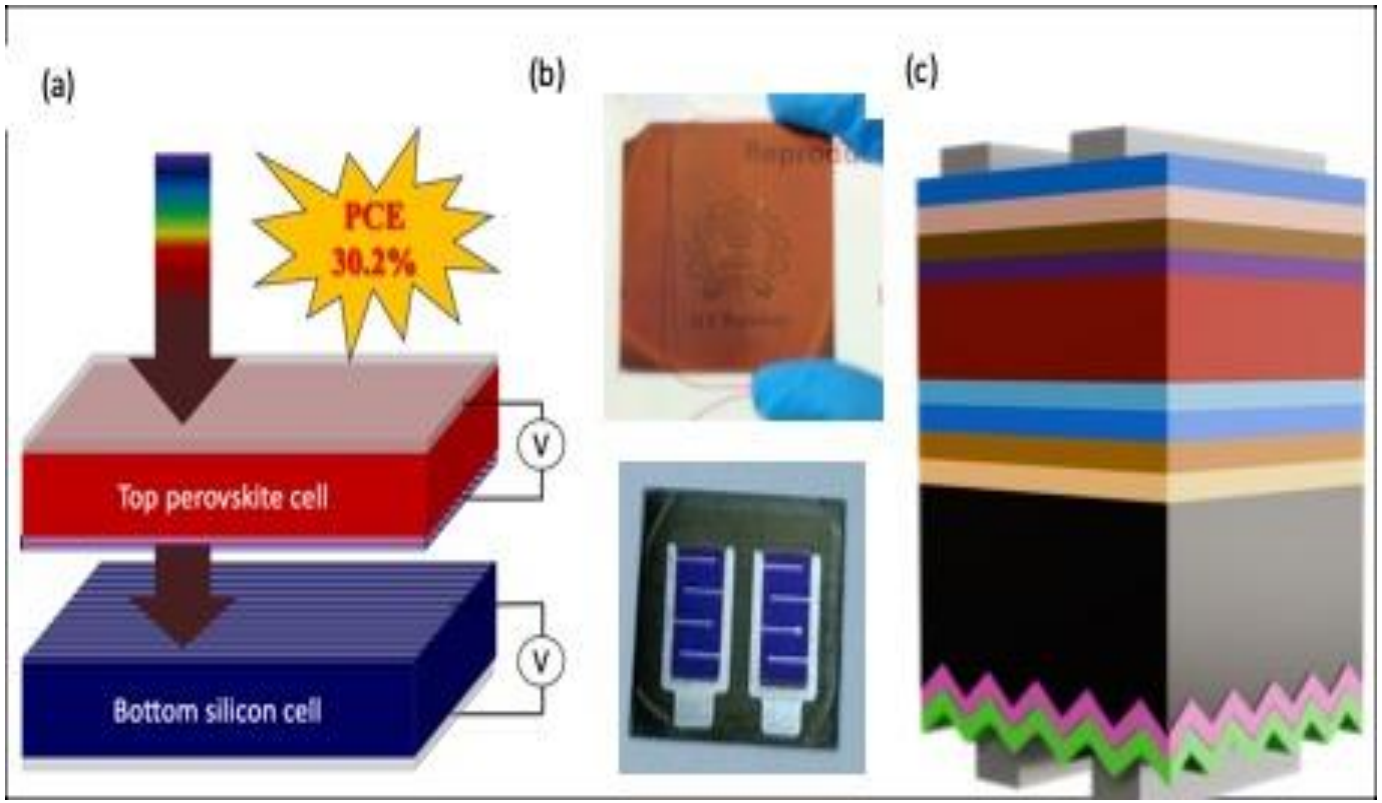
ETPrime

Synopsis

IIT Bombay has developed a technology that significantly enhances the efficiency of Solar Cells to 30%, with potential to reach 45%. The Maharashtra government is actively promoting this innovation, aiming to establish India as a leading player in next-generation solar technology with a 300-MW pilot project in Uran.

Representative Image

Mumbai: In what could transform the solar sector not just in India but the world, the Maharashtra government is trying to make a reality a project of IIT Bombay (IITB) that has managed to increase the efficiency of solar cells to 30% by integrating perovskite on to established silicon solar cells.



- India's total land area is approximately 2.4% of the Earth's total land area.
- India's population currently represents approximately 17.5% of the world's total population.
- 1 GW → ~ 5 km^2 : 300 GW by 2030 and finally the targets in TWs !!!
- Land utilization targets are for TWs → Go for Tandem 4T or 2T only option!!

Perovskite cells offer higher efficiency, lower cost, flexibility, and better low-light performance and ease of manufacturing than silicon based cells

	Parameters	Silicon based cells	Perovskite cells
1	**Theoretical maximum and commercial efficiency**	29-33% (1) (Shockley-Queisser limit) Commercially available: 25.09 % (3)	Theoretical: **45.3%** (2) Commercially available: 26.36% module efficiency (4)
2	**Light absorption**	Can absorb photons with a **wavelength greater than 800 nm** as the bandgap width of silicon is 1.12 eV (6)	Absorb photons with a **wavelength less than 750 nm** as the perovskite bandgap can be tuned to1.67 eV (6)
3	**Raw Material availability**	China controls ~80% of the global supply chain from raw poly-silicon to finished modules (5)	Lead halide and tin halide are widely available, less energy-intensive to process
4	**Raw material Cost**	Lower cost due to abundance and simplicity in processing	Lower cost due to abundance and simplicity in processing
5	**Manufacturing ease**	Utilizes techniques like printing & coating, which are less energy-intensive & more scalable	Established manufacturing with complex and energy intensive processes for monocrystalline silicon and casting for polycrystalline silicon
6	**Durability and lifespan**	25-30 years	Shorter lifespan compared to silicon cells, recent advances in encapsulation and stabilization techniques are extending their operational life

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Key differentiators for ART PV India

1. High Efficiency and stability

We have achieved an lab scale efficiency of 29.84% and target to reach >34% by Dec'25

2. Patents and IP

4 Indian patent, 2 US patents and 5 patents are under application, target to secure by XX

3. Manufacturing knowhow

Developed in-house equipment for manufacturing 1cm2 cell, and 140 cm2 under development, the same can be expanded for G12

4. Proven results in global labs

UV degradation, LID degradation, humidity test, environmental stress test, stability and reliability certified by labs in S Korea and USA

5. Industry partnerships

Partnership for supply of electronic grade salts, base silicon layers and indigenization of manufacturing equipment

6. Access to infrastructure

5000 sqft Clean room at IIT B

Access to IIT Bombay labs and International journals

2500 Sqft upcoming facility near Mumbai

7. Grants and investments

Secured INR 86 Crore grants from MNRE and Waaree Energies

8. Differentiated team

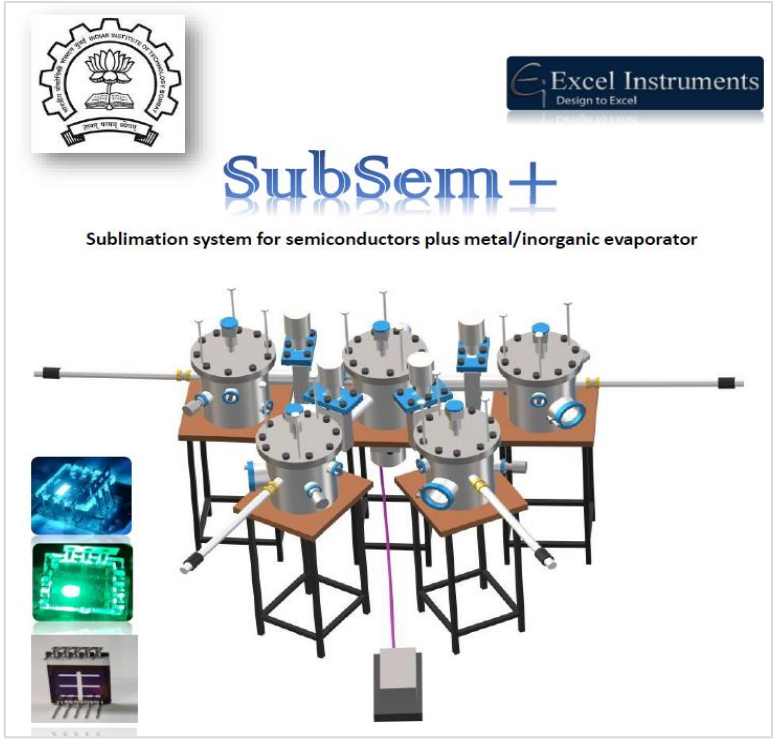
IIT Bombay team of scientist and professors with industry advisors

9.Global recognition

We have been recognized by Nature magazine for next generation of optoelectronic materials for solar cells and display technologies

3. SUBSem+, a proprietary equipment for automated manufacturing of our perovskite cells

SUBSem+



Key features

- Patent granted for “System and Method for Fabrication of Multi-layer Thin Film Optoelectronic Devices “ (Patent Grant No: 464062)
- Equipment developed at 1/20th of the cost

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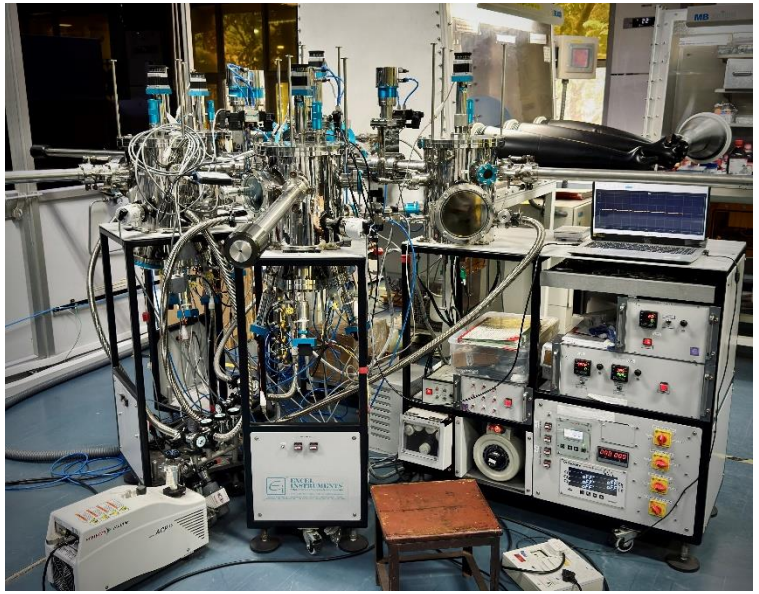
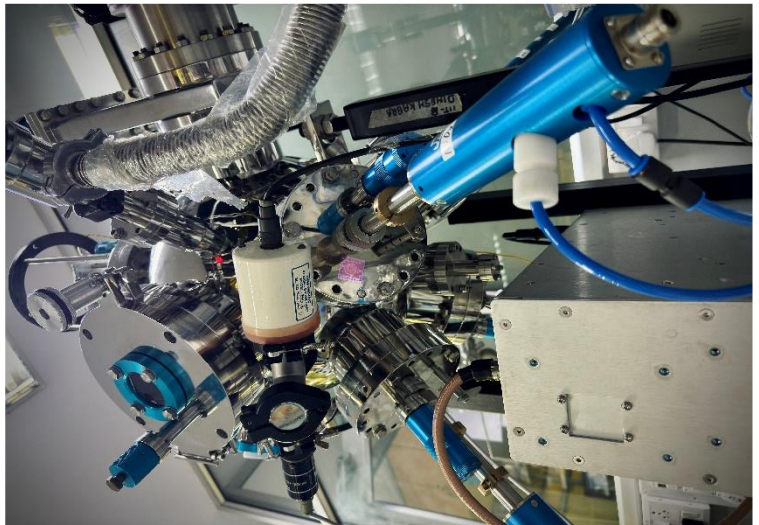
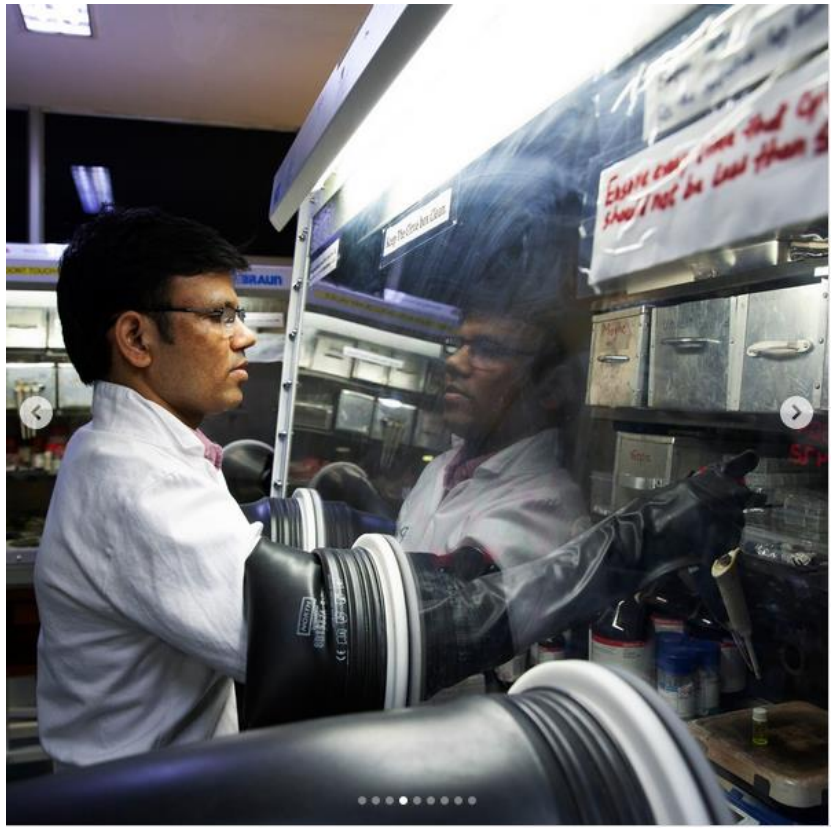
6. We have access to the biggest cleanroom in India for Perovskite cell development and other labs and resources at IIT B

5000 SqFT cleanroom at IIT B[1]

Actual images from labs







1. Under development

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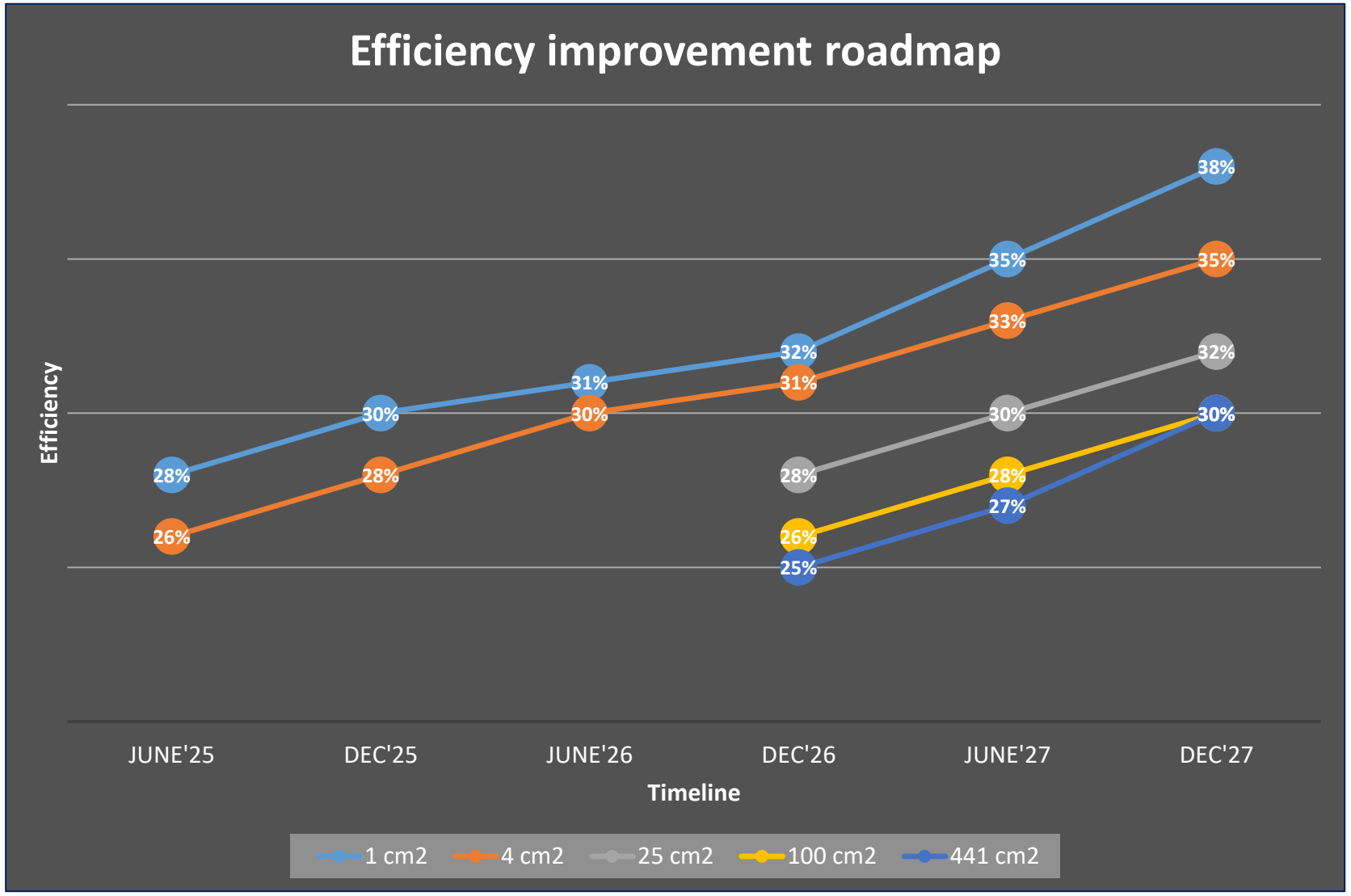
We aim to achieve 30% efficiency of commercial scale Perovskite cell by Dec’27



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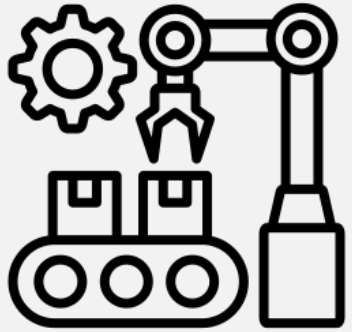
ART PV India can supply perovskites cells, modules license cell manufacturing technology, supply production line and enter niche application for solar cells

01

Solar cell technology licensing

ART PV cell manufacturing technology can be licensed to leading Indian/Global players



03

Cell Manufacturing production line supply

ART PV can supply its proprietary manufacturing equipment to leading cells/ module manufacturers

02

Solar cell to module manufacturing

ART PV itself can become a supplier of the highly efficient perovskites cells and modules

04

Other applications

- Space solar cells (defense ministry project under TDF with ART-PV-under planning)
- ART PV can use the solar cells to manufacture photo-dectectors ($1 Bn market with 7.3% CAGR

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Thank you for your attention

Comments and Questions?