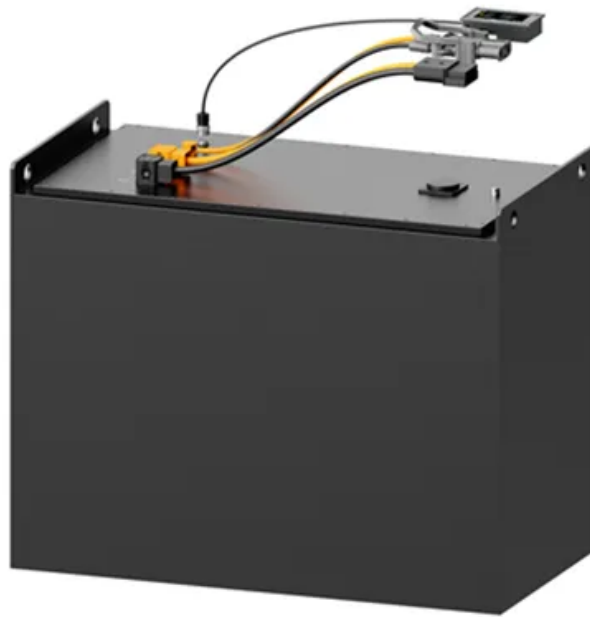


# Oriented nucleation in formamidinium perovskite for photovoltaics





## Overview

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Can in situ monitoring of perovskite crystallization improve the performance of photovoltaic devices?

Here we use in situ monitoring of the perovskite crystallization process to report an oriented nucleation mechanism that can help to avoid the presence of undesirable phases and improve the performance of photovoltaic devices in different film-processing scenarios.

Does Formamidinium lead iodide perovskite have Photoinduced phase segregation and humidity instability?

Formamidinium lead iodide perovskite solar cells commonly suffer from photoinduced phase segregation and humidity instability. Here, the authors design a multifunctional fluorinated additive to promote orientated crystallization of  $\alpha$ -phase, and achieve maximum efficiency of 24.1% and T95 over 1000 h.

What are the photovoltaic parameters of perovskite modules?

Extended Data Fig. 10 Photovoltaic parameters of perovskite modules. Box plots showing the distribution of the a, PCE, b, FF, c, Voc, d, Isc for the control and the PAd-based perovskite modules with an aperture area of 30.86 cm<sup>2</sup>. Centre line, median; box limits, 25 th and 75 th percentiles; curve, normal distribution curve; whiskers, outliers.

How efficient are Formamidinium lead iodide perovskite solar cells?

The unencapsulated devices achieve 24.10% efficiency and maintain >95% of the initial efficiency for 1000 h under continuous sunlight soaking and for 2000 h at air ambient of ~50% humid, respectively. Formamidinium lead iodide perovskite solar cells commonly suffer from photoinduced phase segregation and humidity instability.

Does fluorinated additive stabilize  $\alpha$ -phase of perovskite?



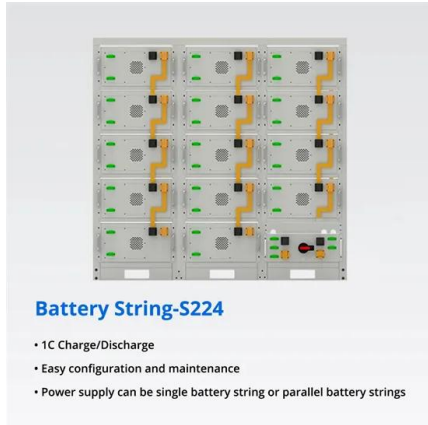
Therefore, we design a multifunctional fluorinated additive, which restrains the complicated intermediate phases and promotes orientated crystallization of  $\alpha$ -phase of perovskite. Furthermore, the additives in-situ polymerize during the perovskite film formation and form a hydrogen-bonded network to stabilize  $\alpha$ -phase.

Is formamidinium lead trihalide a tunable perovskite for efficient planar heterojunction solar cells?

Eperon, G. E. et al. Formamidinium lead trihalide: a broadly tunable perovskite for efficient planar heterojunction solar cells. *Energy Environ. Sci.* 7, 982–988 (2014). Jiang, Q. et al. Surface passivation of perovskite film for efficient solar cells.



# Oriented nucleation in formamidinium perovskite for photovoltaics



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2023?6?21?, Nature ??????????"Oriented nucleation in formamidinium perovskite for photovoltaics"??????  
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## Oriented nucleation in formamidinium perovskite for photovoltaics

Here we use in situ monitoring of the perovskite crystallization process to report an oriented nucleation mechanism that can help to avoid the presence of undesirable phases and improve ...



## Oriented nucleation in formamidinium perovskite for photovoltaics

The black phase of formamidinium lead iodide (FAPbI<sub>3</sub>) perovskite shows huge promise as an efficient photovoltaic, but it is not favoured energetically at room temperature, meaning that the undesirable yellow phases are always present alongside it during crystallization<sup>1-4</sup>. This problem has made it difficult to formulate the fast ...

## Oriented nucleation in formamidinium perovskite for photovoltaics

Oriented nucleation in formamidinium perovskite for photovoltaics Nature Pub Date : 2023-06-21  
 DOI : 10.1038/s41586-023-06208-z Pengju Shi



1,2, Yong Ding 3,4, Bin Ding



### Oriented nucleation in formamidinium perovskite for ...


Here we use in situ monitoring of the perovskite crystallization process to report an oriented nucleation mechanism that can help to avoid the presence of undesirable phases and improve the



### Oriented nucleation in formamidinium perovskite for photovoltaics

The black phase of formamidinium lead iodide perovskite is used to make highly efficient solar cells, and a technique to improve its purity and stability by controlling crystal nucleation could make them even better.

- LiFePO<sub>4</sub>, Battery, safety**
- Wide temperature: -20~55°C**
- Modular design, easy to expand**
- Wall-Mounted&Floor-Mounted**
- Intelligent BMS**
- Cycle Life:> 6000**
- Warranty:10 years**



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### Oriented nucleation in formamidinium perovskite for photovoltaics ...

In this study we observed an oriented nucleation mechanism that originated from the reduced surface energy of a specific crystallographic plane, and this enabled us to avoid the yellow ...



### Oriented nucleation in formamidinium perovskite for photovoltaics

Oriented nucleation in formamidinium perovskite for photovoltaics Pengju Shi<sup>1,2,13</sup>, Yong Ding<sup>3,4,13</sup>, Bin Ding<sup>3,13</sup>, perovskite(100)plane. As a result, compared with the other planes, the surface energy of the perovskite(100) plane was decreased the most (it fell by 64

### Oriented crystallization of FA-based perovskite via

Formamidinium lead iodide (FAPbI<sub>3</sub>) based perovskite solar cells (PSCs) have attracted much attention during the past decade and reached a recorded power-conversion efficiency (PCE) of 25.7%<sup>1</sup>



### "93"??,?Nature!

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Oriented nucleation in formamidinium perovskite for photovoltaics Overview of attention for article published in Nature, June 2023 Altmetric Badge About this Attention Score



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### Perovskite seeding growth of formamidinium-lead-iodide-based

Oriented nucleation in formamidinium perovskite for photovoltaics Article 21 June 2023 Intermediate-phase engineering via dimethylammonium cation additive for stable perovskite solar cells



### Oriented Low-n Ruddlesden-Popper Formamidinium-Based Perovskite

The relatively lower crystallinity and random orientation of quantum well structures hinder carrier transport and limit the performance of formamidinium (FA) based low-n 2D perovskite devices.





### Modulating crystal growth of formamidinium-caesium

We first optimized the nucleation and growth processes of the narrower-bandgap perovskite material, FA 0.88 Cs 0.12 Pbl 3, to satisfy the scaling-up requirements for a commercial printing process



### Oriented nucleation in formamidinium perovskite for photovoltaics

The black phase of formamidinium lead iodide (FAPbI3) perovskite shows huge promise as an efficient photovoltaic, but it is not favoured energetically at room temperature, meaning that the undesirable yellow phases are always present alongside it during



### Oriented nucleation in formamidinium perovskite for photovoltaics

Oriented nucleation in formamidinium perovskite for photovoltaics. Pengju Shi, Yong Ding, Bin Ding, Qiyu Xing, Tim Kodalle, Carolin M Sutter-Fella, Ilhan Yavuz, Canglang Yao, Wei Fan, Jiazhe Xu, Yuan Tian, Danyu Gu, Ke Zhao, Shaun Tan, Xu Zhang, Libing Yao, Paul J Dyson, Jonathan L Slack, Deren Yang, Jingjing Xue, Mohammad Khaja Nazeeruddin, Yang Yang, Rui ...

### Oriented nucleation in formamidinium perovskite for photovoltaics

The black phase of formamidinium lead iodide (FAPbI 3) perovskite shows huge promise as an efficient photovoltaic, but it is not favoured energetically at room temperature, meaning that the undesirable yellow phases are always present alongside it during crystallization.







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