A strategy to reduce defects in inverted perovskite solar cells and improve their performance

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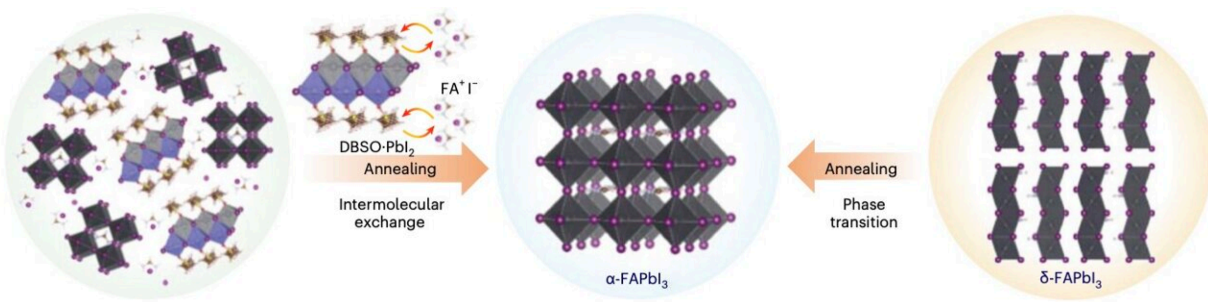

Schematic diagram showing two different crystal growth pathways of the films processed with or without the DBSO additive. Credit: Chen et al, *Nature Energy* (2023). DOI: 10.1038/s41560-023-01288-7

Perovskites, a class of materials with a characteristic crystal structure, have proved to be very promising for the fabrication of solar cells and photovoltaics. One of these materials is lead triodide ($FAPbI_3$), a perovskite that exhibits a long carrier lifetime and a high carrier mobility, as well as good light absorption and electrical conductivity.

Energy researchers and engineers have also been assessing the potential of solar cells with a so-called "inverted" structure, which is simpler than conventional structure and more tolerant to device defects. While their tolerance to defects could make inverted solar cells based on $FAPbI_3$

more stable than solar cells with a regular structure, their power efficiencies have so far been mostly below the established target of 25%.

Researchers at Huazhong University of Science and Technology and other institutes in China recently introduced a design strategy that could reduce defects in $FAPbI_3$-based solar cells, improving their power efficiency. This strategy, introduced in a paper published in *Nature Energy*, involves the application of an additive and a coating agent to the perovskite films integrated in solar cells.

"Power conversion efficiencies of inverted perovskite solar cells (PSCs) based on methylammonium- and bromide-free formamidinium lead triiodide ($FAPbI_3$) perovskites still lag behind PSCs with a regular configuration," Rui Chen, Jinan Wang, and their colleagues wrote in their paper. "We improve the quality of both the bulk and surface of $FA_{0.98}Cs_{0.02}PbI_3$ perovskite films to reduce the efficiency gap."

To improve the performance of inverted PSCs based on $FAPbI_3$, the researchers added a compound to the bulk material that could reduce the defects within it. This compound, called dibutyl sulfoxide (DBSO), has a low volatility and chemically interacts with some materials, influencing their properties or structure.

"First, we use DBSO, a Lewis base additive, to improve the crystallinity and reduce the defect density and internal residual stress of the perovskite bulk," Chen, Wang and their colleagues explained in their paper. "Then, we treat the surface of the perovskite film with trifluorocarbon-modified phenethylammonium iodide ($2CF_3$-PEAI) to optimize the energy levels, passivate defects and protect the film against moisture."

Chen, Wang and their colleagues applied their strategy to a $FAPbI_3$ film, which they then used to create inverted PSCs. They evaluated these solar cells in a series of tests and found that they performed remarkably well, both in terms of stability and energy efficiency.

"The inverted PSCs simultaneously achieve 25.1% efficiency (24.5% from the reverse current–voltage scan measured by a third-party institution) and improved stability," the team wrote in their paper. "The devices maintained 97.4% and 98.2% of their initial power conversion efficiencies after operating under continuous 1-sun air mass 1.5 G illumination for 1,800 h and under damp heat conditions (85°C and 85% relative humidity) for 1,000 h, respectively."

In the future, the strategy proposed by Chen, Wang and their colleagues could be adapted and used by other research teams to engineer more efficient and stable inverted PSCs. While the team specifically applied the DBSO additive and $2CF_3$-PEAI coating to $FAPbI_3$ films, their approach could potentially also help to reduce defects and improve the performance of other perovskite materials.

More information: Rui Chen et al, Reduction of bulk and surface defects in inverted methylammonium- and bromide-free formamidinium perovskite solar cells, *Nature Energy* (2023). DOI: 10.1038/s41560-023-01288-7