Sunlight to power: innovative interface engineering for high-performance perovskite solar cells

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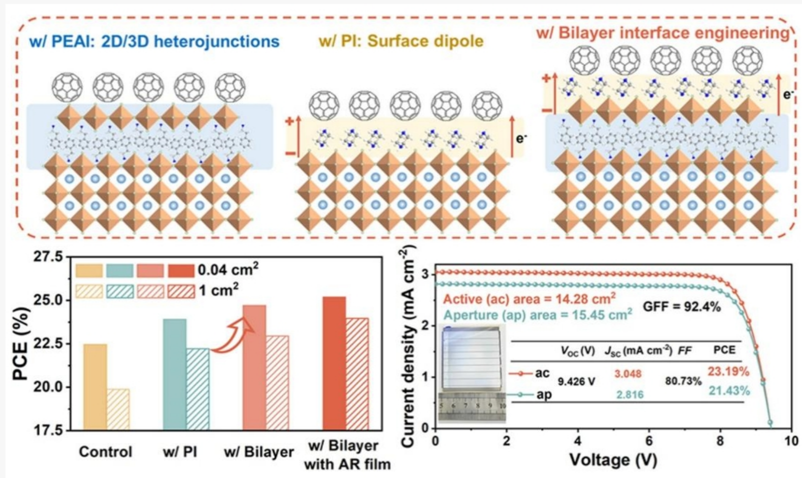

Bilayer Interface Engineering Enhances Efficiency and Scalability of Perovskite Solar Modules.

FAYETTEVILLE, GA, UNITED STATES, April 2, 2025 /EINPresswire.com/ -- A novel study has unveiled a transformative advancement in perovskite solar cells through bilayer interface engineering. This innovative method integrates 2D/3D perovskites with a dipole layer, achieving a remarkable leap in power conversion efficiency and overcoming critical challenges of scalability and stability in large-area solar modules.

Inverted perovskite solar cells (PSCs) have long been heralded for their low hysteresis, cost-effectiveness, and compatibility with tandem applications. However, their large-area counterparts face significant hurdles, with defects hindering carrier transport and reducing operational stability. Current passivation techniques fall short of delivering scalable and reproducible results, making it essential to explore innovative strategies that ensure consistent performance across larger modules. Addressing these obstacles is vital for propelling perovskite solar technology into mainstream adoption.

Researchers at the City University of Hong Kong have introduced a novel bilayer interface engineering technique, published (DOI: 10.1016/j.esci.2024.100308) on September 7, 2024, in eScience. This approach employs phenethylammonium iodide (PEAI) to form 2D/3D heterojunctions, which mitigate surface defects, and piperazinium iodide (PI) to establish surface dipoles, optimizing energy alignment. This dual-layer strategy significantly enhances the efficiency, scalability, and stability of inverted perovskite solar modules (PSMs), offering new pathways for their commercial viability.

The study details how the bilayer interface engineering combines PEAI and PI to address key limitations in scaling up PSMs. PEAI forms protective 2D/3D heterojunctions that passivate defects, while PI layers improve charge extraction through energy-level optimization. The results are striking: small-area devices achieved a record PCE of 25.20%, and larger modules with areas of 1 cm^2 and 14.28 cm^2 achieved 23.96% and 23.19%, respectively. Beyond efficiency, the bilayer-treated devices showcased exceptional stability, retaining over 93% of their performance after 1280 hours under continuous illumination at 45°C. Crucially, the method is compatible with large-scale manufacturing, ensuring uniformity and consistent results. This innovative approach marks a pivotal step in the evolution of efficient, stable, and scalable solar modules, setting the stage for widespread adoption.

Prof. Alex K.-Y. Jen, a leading author of the study, remarked: "This research highlights the revolutionary impact of bilayer interface engineering in overcoming long-standing challenges in perovskite solar technology. By ensuring both high efficiency and scalability, we are now closer than ever to unlocking the commercial potential of perovskite solar modules."

The implications of this breakthrough extend far beyond the laboratory. This bilayer interface technology lays the foundation for the mass production of efficient, durable, and cost-effective perovskite solar modules. As further development continues, this innovation is poised to reshape renewable energy, providing a scalable and sustainable solution to meet global energy demands.

References
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