Researchers claim new world record for tandem solar cell efficiency

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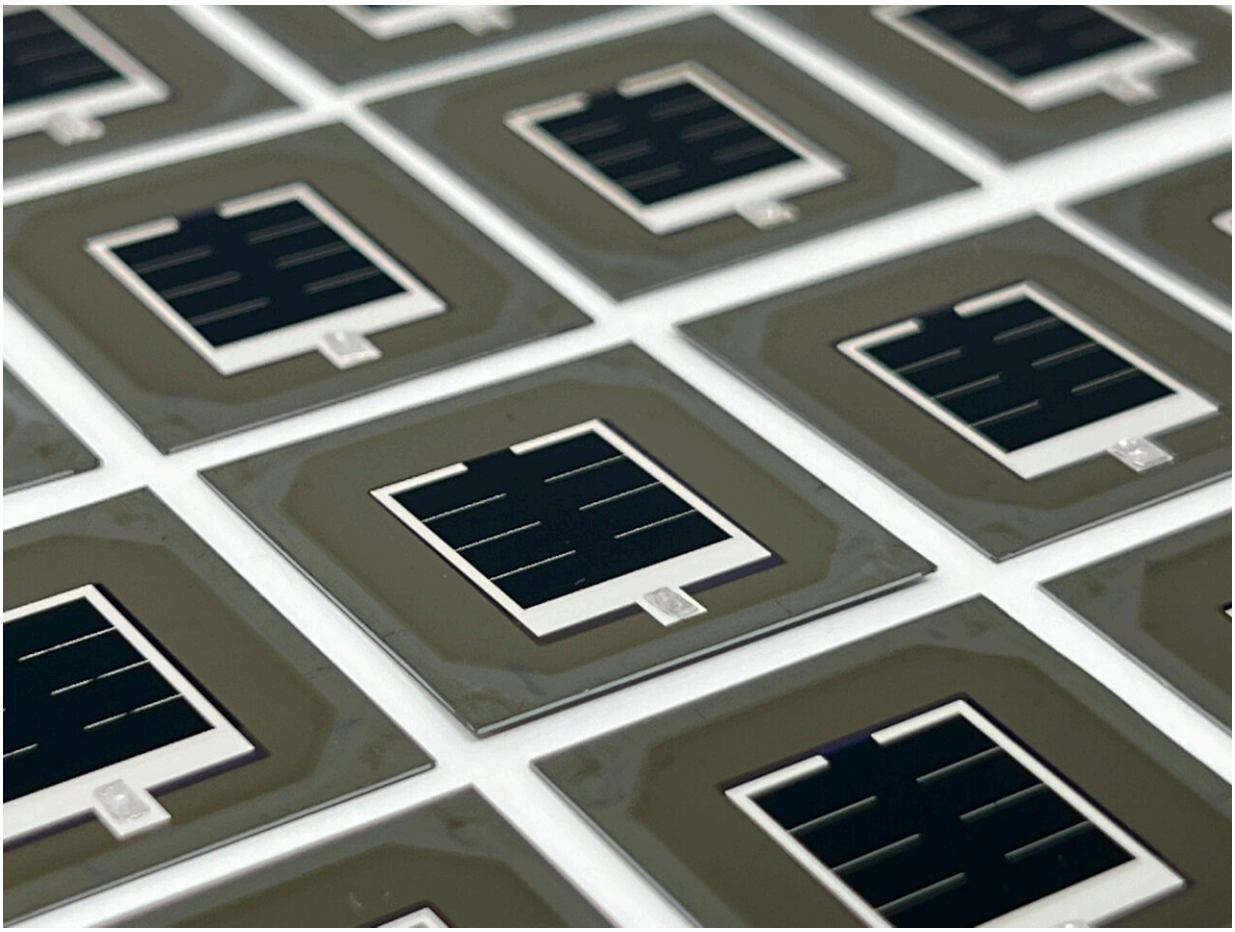
KAUST postdoctoral fellow Dr. Esma Ugur displays the perovskite/silicon tandem solar cell that she and team researchers in the KAUST Photovoltaics Laboratory developed, recognized as the world's most efficient silicon/perovskite tandem solar cell at 33.2% PCE. Credit: 2023 KAUST

Crystalline silicon solar cells dominate the global photovoltaic market with module efficiencies of around 20-22%. However, the field of solar energy is wanting for innovative materials and approaches that yield even higher efficiencies in support of global renewable energy goals.

Tandem solar cells combining silicon and perovskite sub-cells are widely regarded as a very promising, high-performing and viable alternative to conventional crystalline solar cells, and King Abdullah University of Science and Technology (KAUST) is leading the charge. Researchers in the KAUST Photovoltaics Laboratory (KPV-Lab) of the KAUST Solar Center have produced a perovskite/silicon tandem solar cell with a power conversion efficiency (PCE) of 33.2%—the highest tandem device efficiency in the world to date, surpassing that of Helmholtz Zentrum Berlin's (HZB) record at 32.5% PCE.

The tandem device was certified by the European Solar Test Installation (ESTI) and listed at the top of the National Renewable Energy Laboratory's (NREL), Best Research-cell Efficiency Chart.

Led by Dr. Stefaan De Wolf, professor of material science and engineering and interim associate director of the KAUST Solar Center, the team has steadily been perfecting the perovskite/silicon tandem cell concept since 2016—developing new materials, methods and device structures, and tackling fundamental challenges, such as how to uniformly cover the micrometer-sized pyramidal surface of silicon cells with perovskite material.



Close view of the perovskite/silicon tandem solar cell that researchers in the KAUST Photovoltaics Laboratory developed, recognized as the world's most efficient silicon/perovskite tandem solar cell at 33.2% PCE. Credit: 2023 KAUST

The resulting tandem solar cell combines perovskite top cells on industrially compatible, two-sided textured silicon bottom cells. The perovskite top layer absorbs blue light best, while the silicon foundation absorbs red light best. The combination of these materials maximizes the capture and conversion of sunlight into electricity more efficiently than the conventional single-junction silicon analogs.

The innovation is a significant breakthrough in the field of solar energy at a time when market predictions estimate that tandem perovskite/silicon technologies will comprise more than $10 billion of the global photovoltaic market share by 2032.

"This new record is the highest PCE of any two-junction solar cell under non-concentrated light, attesting the tremendous promise of perovskite/silicon tandems to deliver ultra-high performance photovoltaic modules, which is critical to rapidly achieve renewable energy goals towards combatting climate change," De Wolf said.

The collective knowledge and skills of several lead researchers have contributed to the recent achievement, in particular Dr. Esma Ugur, who specializes in optical spectroscopy and the analysis and visualization of cell defects; Dr. Erkan Aydin, an expert in the scalability and stability of ultra-efficient tandem solar cells; and Dr. Thomas Allen, who focuses on c-Si bottom cell development.

The team is currently exploring scalable methods to produce industrial-scale perovskite/silicon tandem cells with areas exceeding 240 square centimeters, as well as strategies to obtain highly stable tandem devices that will pass the critical industrial stability protocols.

Provided by King Abdullah University of Science and Technology