An industrially viable competitor to silicon-based solar cells is in the works

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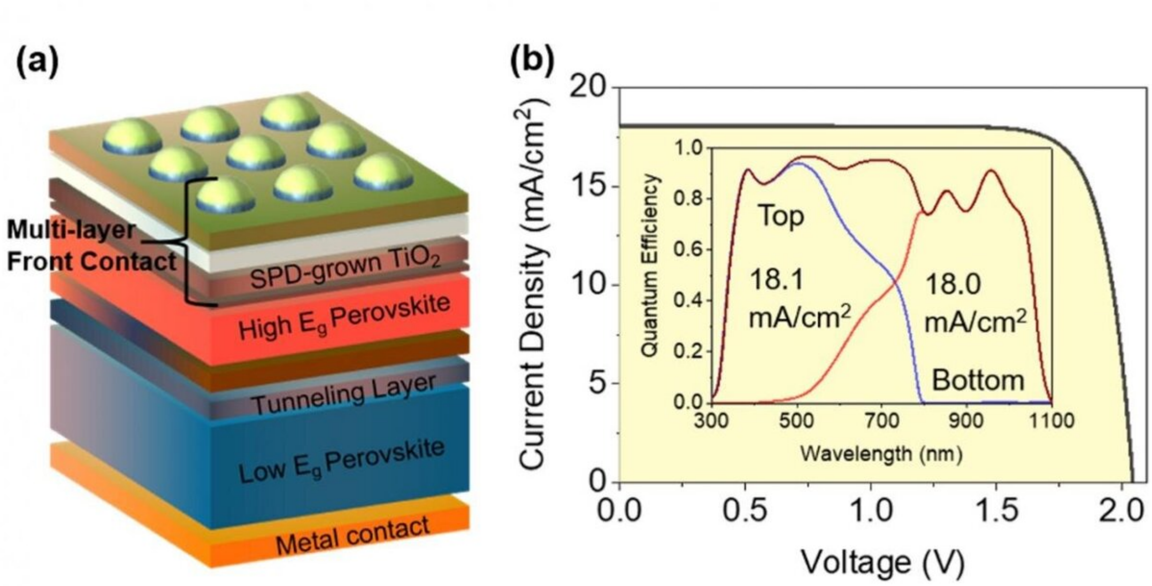


(a) Schematic diagram of the perovskite/perovskite tandem solar cell, and (b) current-voltage characteristic curves of the best-investigated perovskite/perovskite tandem solar cell. Inset shows quantum efficiency for top perovskite and bottom perovskite. Credit: Kanazawa University

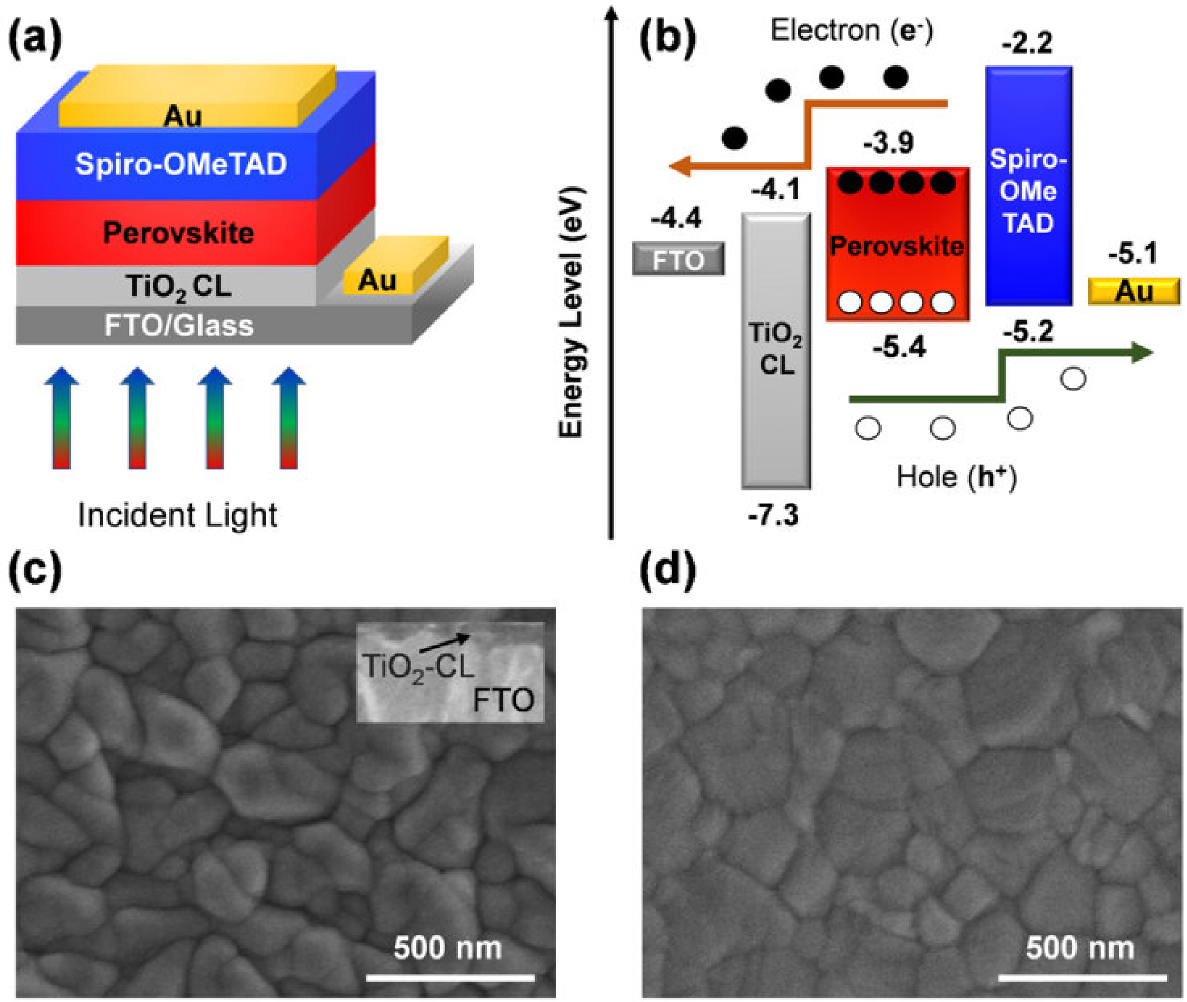
Solar cells are excellent renewable energy tools that use sunlight to drive an electrical current for power. They've been used to power homes since the 1980s, and their performance and production cost have improved dramatically since then. The most common solar cells, based on silicon, work well for a long time. They retain more than 80% of their functionality even after 25 years. However, the efficiency—i.e., how much of the incoming sunlight is converted to electrical power—of commercial-scale silicon solar cells is currently only around 20%.

Maximizing solar cells' energy conversion efficiency will improve their competitiveness compared to fossil fuels and help optimize them as a sustainable energy source. Researchers have intensively focused on an alternative to silicon: perovskite materials to enhance solar cells' efficiency. Designs based on such materials must meet certain requirements, such as ease of fabrication on a large scale, and minimize reflected—i.e., wasted—light.

In a recent study published in *Nano-Micro Letters,* researchers from Kanazawa University applied a thin metal oxide film—reproducible, uniform, and compact—onto a perovskite solar cell. The researchers used a combination of lab work and computational studies to evaluate their solar cell design performance fairly.

"We used spray pyrolysis to deposit a front contact layer of titanium dioxide onto a perovskite solar cell," explains Md. Shahiduzzaman, lead and corresponding author. "This deposition technique is common in the industry for large-scale applications."

Upon finding an optimum thickness for the front contact layer, the researchers measured an energy conversion efficiency of 16.6%, assuming typical sunlight conditions. As mentioned, this isn't quite as good as commercial silicon-based solar cells. Nevertheless, electromagnetic simulations were a powerful tool for predicting the possible energy conversion efficiency limit by optimizing specific parameters.



(a) The schematic diagram and (b) corresponding energy levels of the investigated single-junction planar perovskite solar cell. Top-view scanning electron microscopy (SEM) micrographs of (c) spray-pyrolysis deposited TiO_2 compact layer (the inset shows the cross-sectional view of the TiO_2), and (d) perovskite film deposited on TiO_2-CL/FTO substrate. The TiO_2 precursor solution has a concentration of 0.35 M and a thickness of 70 nm. Credit: Kanazawa University

"Computational simulations suggest that the energy conversion efficiency of perovskite/perovskite tandem solar cells could go beyond 30% by a multi-layer front contact," says Md. Shahiduzzaman, lead and corresponding author. "This is close to the theoretical efficiency limit of silicon-based solar cells."

Additional challenges remain. For example, there must be a clear demonstration that the researchers' solar cells continue functioning at least as long as silicon-based analogs. In addition, the perovskite solar cells are based in part on lead, a highly toxic metal. Ideally, there should be a clear protocol for recycling the devices instead of simple—and dangerous—disposal. Shahiduzzaman is optimistic that such technical challenges can be overcome with a focused research effort.

More information: Md. Shahiduzzaman et al, Spray Pyrolyzed TiO2 Embedded Multi-Layer Front Contact Design for High-Efficiency Perovskite Solar Cells, *Nano-Micro Letters* (2021). DOI: 10.1007/s40820-020-00559-2

Provided by Kanazawa University