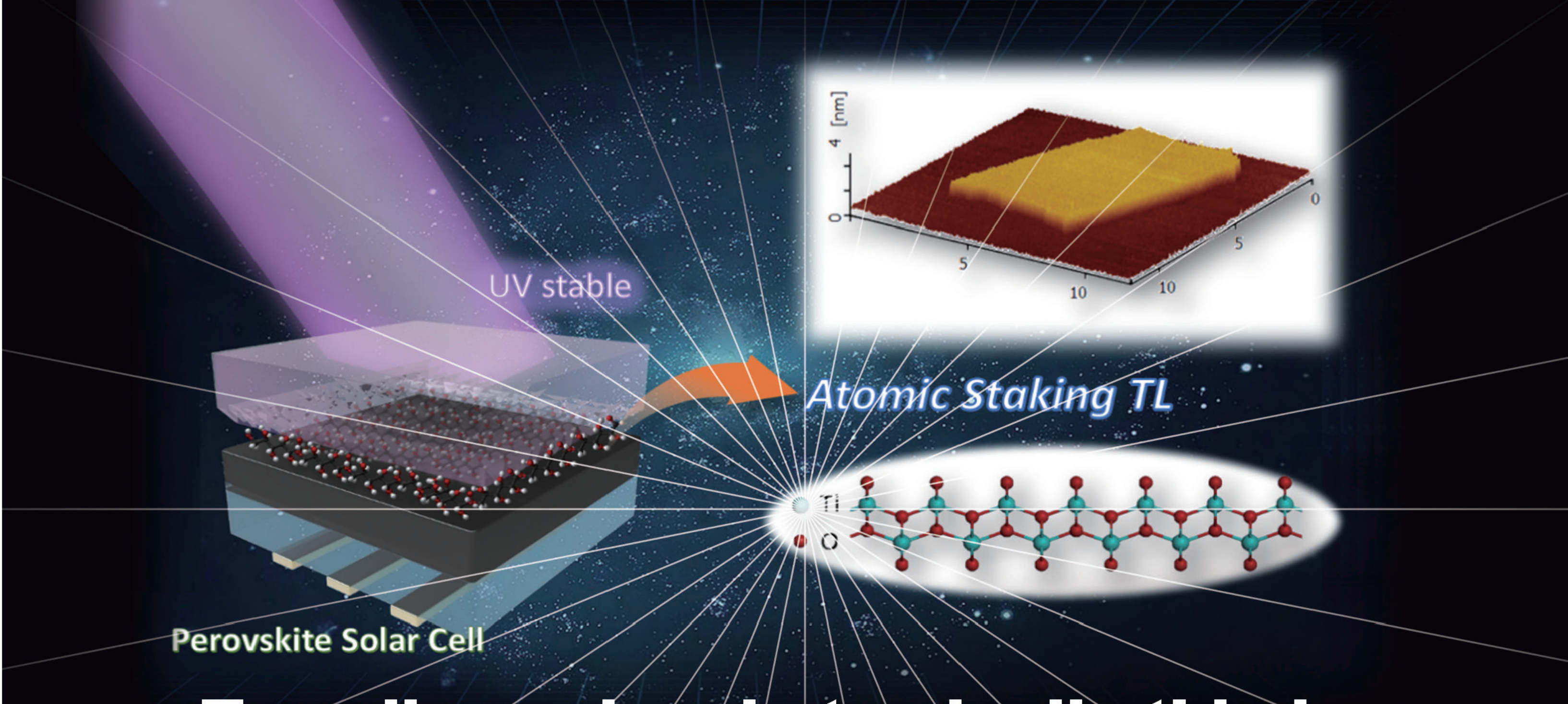

Two-dimensional atomically thin layer titania for perovskite solar cells with extended UV stability

An international collaboration research team consisting of members from National Taiwan University (NTU) and the National Institute of Materials Science (NIMS), Japan, led by Professor Chun-Wei Chen at the Department of Materials Science and Engineering, NTU, recently demonstrated the use of novel two-dimensional (2D) atomic sheets of metal oxide titania as a building block for a new type of atomic stacking transporting layer (ASTL) in perovskite solar cells. The unique ASTL, which consists of atomic-thickness sheets of the metal oxide titania, can be fabricated through the low-temperature solution-processed atomic layer-by-layer deposition technique. Most importantly, perovskite films in solar cell devices using the ASTL of titania atomic sheets show significantly inhibited UV-induced degradation compared to those in devices using the conventional high-temperature sintered TiO_2 counterpart, which usually causes notorious instability in devices under UV irradiation.

Organic–inorganic lead halide perovskite solar cells have achieved remarkable progress with rapidly increasing power conversion efficiencies (PCEs), reaching over 20% in the past few years. For high-performance perovskite solar cells, electron transporting layers (ETLs) and hole transporting layers (HTLs) are usually used to extract both photogenerated electrons and holes from the perovskite light absorber layers, directing them toward two opposite electrodes. In addition, appropriate design of the interfacial ETLs and HTLs with well-matched energy levels between the electrodes and perovskite light absorbers can maximize the built-in potential and the open circuit voltage of devices. The most popular ETL in high-performance perovskite solar cells is the inorganic compact TiO_2 (c-TiO_2) layer. However, high-temperature sintering (450–550 °C) is usually required to prepare the c-TiO_2 layers, which may limit the deposition of perovskite solar cells on thermally sensitive substrates. Another critical issue of using the conventional c-TiO_2 layer in perovskite solar cells is the UV-light-induced degradation of devices. It is well known that conventional TiO_2-based perovskite solar cells exhibit inherent instability under UV light irradiation, as oxygen vacancies at the TiO_2 surface become deep traps and result in significant charge recombination and decomposition of perovskite thin films. Until now, TiO_2 nonetheless may have been the most efficient compact layer or ETL in high-performance perovskite solar cells; however, the issue concerning the inherent instability and UV-induced degradation of such devices may greatly limit the commercial deployment of TiO_2-based perovskite solar cells.

This work demonstrates the utilization of 2D atomic sheets of titania ($Ti_{1-\delta}O_2$) as a building block for a new type of atomic stacking transporting layer (ASTL) in perovskite solar cells. The ASTL, which consists of 2D layered atomic sheets of titania, can be fabricated through the solution-processed self-assembly atomic layer-by-layer deposition technique. Most importantly, perovskite solar cell devices using this ASTL show significantly inhibited UV-induced degradation of perovskite films compared to that obtained using the conventional c-TiO_2 ETL due to the unique features of high UV transparency and negligible (or very low) oxygen vacancies of 2D titania atomic sheets. The utilization of ASTLs consisting of ultrathin 2D oxide layered materials thus provides a new opportunity to develop stable and high-performance perovskite solar cells based on fully solution-processable fabrications.

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References

Chen, T., Lin, C., Li, S., Tsai, Y., Wen, C., Lin, W. J., . . . Osada, M. (2018). Self-Assembly Atomic Stacking Transport Layer of 2D Layered Titania for Perovskite Solar Cells with Extended UV Stability. *Advanced Energy Materials, 8, 1701722*. doi:10.1002/aenm.201701722

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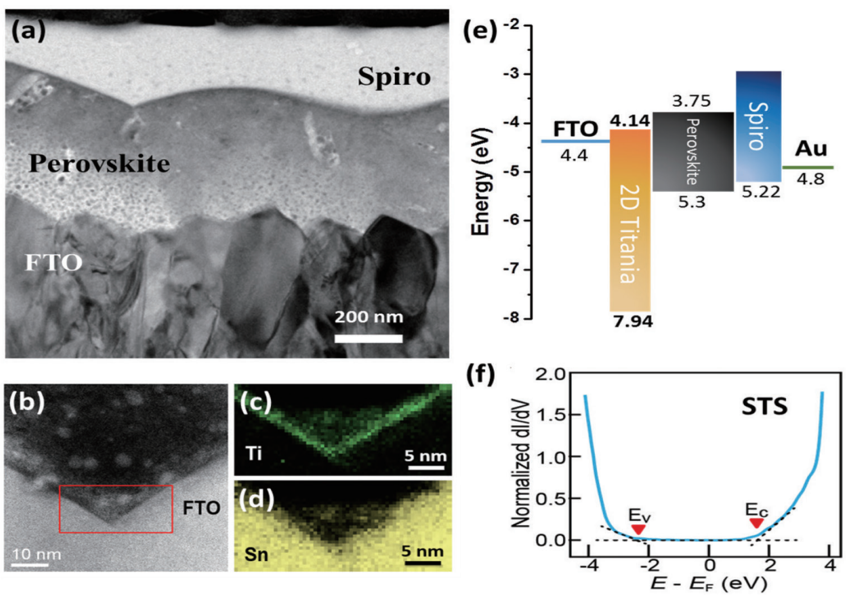

Figure 1. The perovskite solar cell consisting of an ASTL of 2D titania atomic sheets. (a) A cross-sectional TEM image of the perovskite solar cell with atomically thin 2D titania as an electron transporting layer. (b) A cross-sectional HAADF-STEM image of the perovskite solar cell. (c) and (d) EELS elemental maps of Ti and Sn, respectively, in the labeled area of (b).

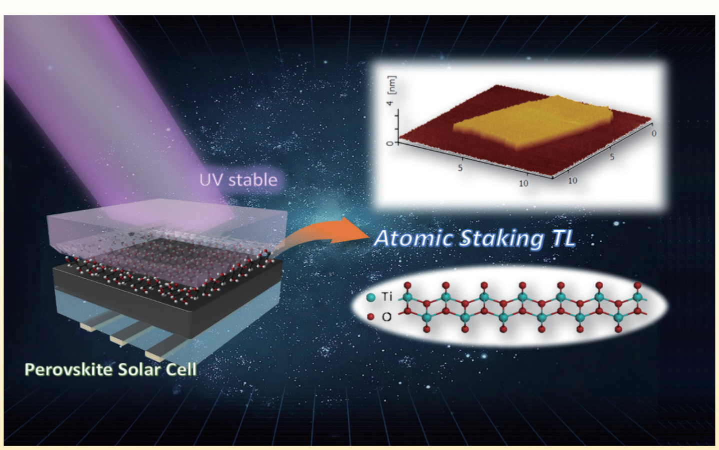

Figure 2. Self-assembly atomic stacking transport layer (ASTL) of 2D layered titania for perovskite solar cells with extended UV stability.