Strategy for Hole-Transport-Material-Free Perovskite Solar Cells Using Carbon-Based Electrodes (Vol. 2)

Perovskite solar cells, which can be produced using a simple low-temperature process, are expected to be the next generation of high efficiency solar cells. The results of this assessment, which used carbon nanotubes in place of hole-transport-layer/Au electrodes, revealed that introducing functional groups into the tubes improved the reproducibility and stability of battery characteristics. Enhancing the reciprocal action in the bonded interface between the perovskite crystals and the nanotube electrodes is the key for the improvement.

- Although perovskite solar cells have been reported to have a power generation efficiency of more than 25%, reproducibility and stability have become issues due to degradation of the perovskite layers and hole-transport-layer/Au electrodes. There have also been challenges surrounding the small dimensions of the cells.
- Carbon-based electrodes have been examined for improving stability and reducing cost of perovskite solar cells. This assessment reveals that carbon nanotubes with functional groups have a strong reciprocal action with perovskite crystals, which contributes to improved performance and subsequent stability of battery properties over time (Figure 1: right) [1].
- The surface bonded not by mere intermolecular forces but by hydrogen bonds between the functional group of the nanotubes and the crystal has strong adhesive force. This property leads to interfacial reconstruction at room temperature through ion diffusion, which is believed to enhance the stability and reproducibility of the new interface (Figure 1: left).

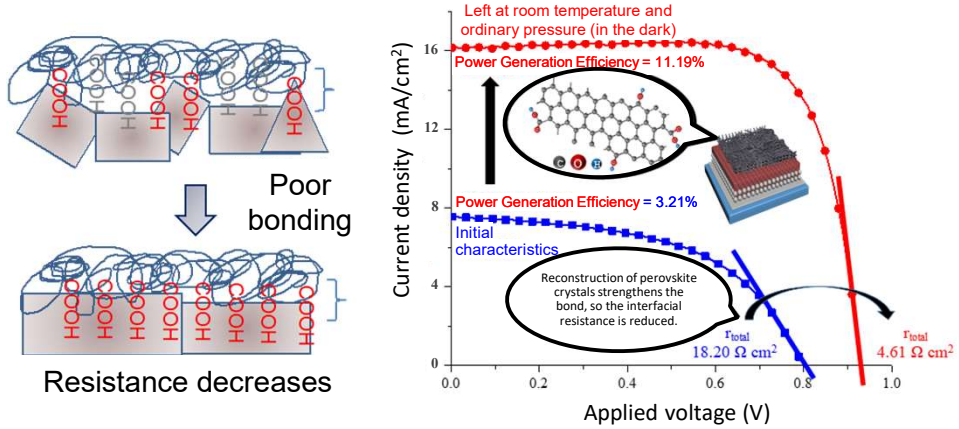

Figure 1: Schematic of efficiency improvements through interfacial reconstruction and solidification

Proposals for Policy Development

The assessment reveals that the strength of the bond at the interface between the perovskite crystal layer and the carbon nanotube electrodes is a key influencer of cell durability. Basic research on the following issues must be performed to allow for the manufacture of large dimension, high-efficiency solar cells for practical use.

1) Investigations into a fabrication process to optimize the bonding of perovskite and carbon materials.
2) Improvement of hole collection efficiency by controlling the electron structure (work function) of carbon electrodes.
3) A quantitative investigation of the degradation mechanism of carbon electrode batteries through clarifying reversible/irreversible reactions.

[1] Jie Chen et al., MAPbI3 Self-Recrystallization Induced Performance Improvement for Oxygen-Containing Functional Groups Decorated Carbon Nanotube-Based Perovskite Solar Cells, Sol. RRL, 3, 2019. https://doi.org/10.1002/solr.201970121.