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The next direction of high-efficiency perovskite solar cells: all-non-toxic Sn-perovskite tandem solar cells

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The efficiency of lead perovskite solar cells (Pb-PVK-PV) has now exceeded 26% (1,2). Tandem cells consisting of Pb-PVK-PV as the top cell and Si solar cell as the bottom cell have attracted much attention as solar cells with higher efficiency than Pb-PVK-PV. The certified efficiency has now reached 32.5% (2). In addition, especially from the perspective of flexible tandem solar cells, all-perovskite tandem solar cells have advantages over tandem cells consisting of Pb-PVK-PV (top)/inorganic solar cell (bottom) because both the top and bottom cells are manufactured using a low-temperature printing process. The efficiency of all-perovskite tandem solar cells is reported to be 28% (1). However, the toxicity of Pb has long been criticized, and for this reason, people have developed various Pb substitutes: Sn, Ge, etc. Among them, Sn-based perovskite solar cells have developed rapidly and have now exceeded 15%. Since it is very difficult to further improve the efficiency of single-cell Sn-based perovskite solar cells, in order to further manufacture non-toxic perovskite solar cells, we need to develop new device structures. Our research focuses on the efficiency breakthrough of wide-bandgap Sn-based perovskite solar cells. This is to prepare for our subsequent GIGS/Sn-PVK tandem cells. In order to further improve the efficiency of wide-bandgap solar cells, we introduced ferrocene derivatives at the PEDOT:PSS/PVK interface. By repeatedly optimizing the concentration of the modifier, we successfully increased the efficiency of the WBG Sn PSC to more than 11%. At the same time, we successfully prepared a CIGS/WBG-Sn-PVK tandem solar cell with an efficiency of more than 14%. This is the world's first report on all-lead-free perovskite tandem solar cells, and it also provides guidance and help for further improving the efficiency of Sn-based solar cells.

Key words: CIGS/PVK; Lead-free and non-toxic; wide bandgap Sn PSCs; Ferrocene derivatives.

References:

1. Martin Green, et al., Prog Photovolt Res Appl, 2022;30:687–701, Efficiency Table 60.
2. NREL 2024 https://www.nrel.gov/pv/cell-efficiency.html.