Design of Photovoltaic-grade Interface Passivation Layers to Enhance the Efficiency of the Perovskite Solar Cells

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Abstract

The efficiency of Perovskite solar cells (PSCs) has shown remarkable progress in recent years, making them promising candidates for next-generation photovoltaic technology. However, challenges remain in achieving stable and high-efficiency performance, particularly concerning interface passivation. This study focuses on the design and optimization of photovoltaic-grade interface passivation layers to enhance the efficiency of PSCs. A comprehensive investigation into the effects of different passivation materials, deposition techniques, and interface engineering strategies is conducted to elucidate their impact on device performance. The role of using the NH_4Cl and PMMA: PCBM passivation layers in mitigating charge recombination processes at the perovskite/electron transport layer and perovskite/hole transport layer interfaces is elucidated. Additionally, the influence of passivation on device stability and hysteresis effects is investigated to ensure long-term performance reliability. The results demonstrate that tailored passivation layers effectively suppress interface recombination, leading to remarkable long-term stability after 116 days (2784 hours) of storage under dark conditions and in Ar ambient, achieving a PCE of 19.4%. Moreover, insights gained from this study contribute to a deeper understanding of the underlying mechanisms governing PSC operation and provide guidelines for the rational design of interface passivation strategies. Ultimately, this research facilitates the development of high-performance PSCs with enhanced efficiency, stability, and commercial viability, thereby advancing the prospects of perovskite-based photovoltaics as a sustainable energy solution.

Keywords

Passivation, Electron Transport Layer, Long-Term Stability

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