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The Application of Interface Modification in Improving the Stability of Perovskite Solar Cells

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Abstract: In recent years, perovskite solar cells (PSCs) have experienced rapid development, driven by their exceptional photovoltaic performance, remarkable power conversion efficiency, and straightforward fabrication processes. However, the issue of stability has remained a significant challenge hindering their commercialization. This article explores the effects of various environmental factors, including temperature, humidity, and light exposure, on the stability of PSCs, with a particular focus on the structural characteristics of the cells themselves. It further delves into the mechanisms that influence the stability of PSCs, reviewing recent advancements in areas such as the defect passivation of perovskite films and the optimization of energy levels within PSCs. The article concludes by offering an outlook on the ongoing trends in interface modification techniques in PSCs, with the aim of enhancing their long-term stability and enabling their broader and more practical application in the future. Through these efforts, the commercialization and widespread use of PSCs could be significantly advanced.

Keywords: perovskite, solar cells, interface modification

1. Introduction

In recent years, perovskite materials have attracted widespread attention due to their excellent optical properties and outstanding electrical characteristics. These materials can be applied in the field of solar cells, breaking the barriers of traditional solar cells, such as low photoelectric conversion efficiency, high cost, and heavy reliance on rare metals. They have become a highly promising new photovoltaic technology—perovskite solar cells (PSCs). However, achieving excellent stability for commercialization remains a key bottleneck in their development. Currently, laboratory methods often involve optimizing the device structure to improve stability, such as using flexible substrates and multi-layer structure designs [1]. Large-scale production requires the introduction of buffer layers or heterojunctions to meet performance requirements, which results in high costs, complex synthesis, and difficulties in controlling coating uniformity during production. In addition, methods such as vapor-phase treatment, optimized encapsulation technologies, and improvements to the hole transport system offer significant advantages for the large-scale production of perovskite solar cells [2]. Particularly, perovskite interface modification technologies can produce new types of cells with high efficiency, light weight, good flexibility, and long lifespan, which are considered the most ideal preparation solutions for future large-scale production. In the future, perovskite solar cells will transition from the laboratory to various fields such as military, medical, drone, smart sensors, and aerospace, and their practical application prospects will become even brighter [3].

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2. Basic principles and structure of perovskite solar cells

The working principle of PSCs with an n-i-p structure is discussed as an example. When the perovskite light-absorbing layer is irradiated with photons whose energy is greater than or equal to the bandgap, electrons in the valence band of the perovskite are excited to the conduction band, creating a hole in the valence band. The electron and hole are bound together through Coulomb interaction, forming an exciton. The photo-generated excitons easily dissociate into free electrons and holes. Due to the high mobility of charge carriers and the built-in electric field, free electrons and holes diffuse in random thermal motion, transporting from the perovskite light-absorbing layer to the interface of the ETL and HTL. The electrons and holes are then transmitted through the ETL and HTL to the negative and positive electrodes of the cell, respectively. The two electrodes create a potential difference, generating a stable current in the external circuit.

In recent years, due to the excellent photoelectric conversion performance exhibited by planar heterojunction structures, they have become the main research direction for perovskite solar cells. Based on the arrangement of functional layers, planar structures can be specifically classified into two device configurations: the regular (n-i-p) and inverted (p-i-n) types. The structural difference between n-i-p and p-i-n lies in whether the transport layer that grows first on the substrate is the ETL or the HTL [4].

The following explanation uses the n-i-p type planar structure as an example (as shown in Figure 1). It has a unique structure composed of three layers of materials stacked in sequence: the electron transport layer made from n-type semiconductor materials, the perovskite active layer, and the hole transport layer made from p-type semiconductor materials. Therefore, the planar structure is also figuratively referred to as a "sandwich" structure.

In order to achieve the optimal performance of perovskite solar cells, from an optical perspective, the electron transport material (ETM) should have high transparency in the visible light range with short wavelengths. This allows more photons to pass through the ETL and be better absorbed by the perovskite layer, generating more photo-generated carriers and improving device performance [5-6]. From an electrical perspective, the n-type semiconductor used as the electron transport layer (ETL) should have high electron mobility, high transparency, and an energy band structure that matches the perovskite active layer, in order to effectively collect electrons and suppress hole diffusion. Additionally, a smooth ETL layer not only helps the perovskite layer grow with high crystallinity while maintaining a uniform and thin film, but also cleverly prevents direct contact between the perovskite active layer and the bottom electrode, which could cause a short circuit.

The HTL plays a crucial role in the efficiency and stability of PSCs. HTLs are mainly divided into two categories: organic and inorganic. Among them, organic hole transport materials (HTMs) are widely used in PSCs due to their excellent film-forming ability and relatively high hole mobility. Currently, the champion efficiencies of various PSCs are mostly achieved using organic materials as the HTL [7]. They can effectively transport the holes generated in the perovskite light-absorbing layer to the metal electrode. The preparation process of Spiro-OMeTAD is mature and relatively controllable, making it the most efficient HTL material discovered so far. However, studies have shown that although defect passivation treatments are often performed between the perovskite surface and the charge transport layers to improve the cell's performance, the surface treatment solution may affect the heterojunction interface energetics, thereby limiting the enhancement of PSC stability through defect passivation on the perovskite surface [8].

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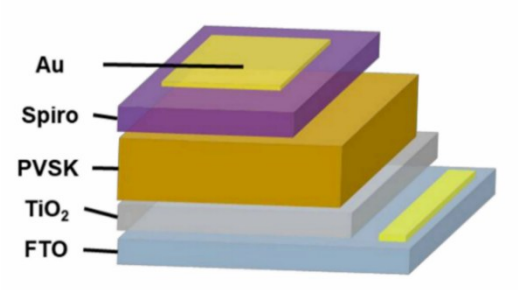

Figure 1: A common perovskite solar cell structure[9]

3. Analysis of stability issues

Perovskite solar cells have attracted significant attention in the photovoltaic field due to their high photoelectric conversion efficiency and low-cost fabrication process. Currently, they meet the industrialization requirements in terms of cost and efficiency, but stability remains a critical challenge to be addressed for large-scale applications. Among the factors affecting the stability of perovskite solar cells, interface-related issues not only cause degradation in cell performance but also, in combination with environmental factors, exacerbate the instability of the cell. The following explains this using $MAPbI_3$ as an example.

The organic cations (MA^+/FA^+) and halide ions (I^-/Br^-) present within $MAPbI_3$ [10]. Under light or heating conditions, it decomposes into PbI_2 and the volatile MAI. This is due to the difference in the thermal expansion coefficients between the perovskite, the charge transport layer, and the substrate, which creates additional stress at the interface, accelerating the migration of ions within the perovskite and even causing interface delamination, thus affecting the device stability.

Water molecules can easily penetrate the device through the crystal boundaries of the perovskite. $MAPbI_3$ (methylammonium lead iodide) can undergo hydrolysis, and the resulting HI forms a porous PbI_2 layer, which then damages the device structure. In addition, humidity variations may induce the formation of intermediate hydrated phases, leading to lattice expansion and causing performance degradation.

On the other hand, the stability of perovskite solar cells is closely related to the defects within the material [11]. The presence of a large number of defects in perovskite can limit the efficiency of the device while accelerating phase transitions in the light-absorbing layer, significantly affecting its stability. Currently, layered structures remain the dominant configuration for perovskite devices. In these devices, the defect concentration at the interfaces is generally higher than that in the light-absorbing layer, and most of these defects are deep-level defects, which can have a negative impact on the long-term stability of the device [12]. In addition, perovskite solar cells can accumulate mechanical stress during long-term operation. This mechanical stress typically accumulates at the interlayer interfaces of the perovskite device, leading to the formation of cracks, significantly reducing the stability of the cell [13].

4. The mechanism of interface modification

4.1. Defect passivation

Perovskite films are mainly prepared through solution-based methods, involving processes such as solvent evaporation and crystal grain growth. Lattice mismatch is a common issue in the preparation of perovskite films, especially during heteroepitaxial growth. The mismatch in lattice constants can lead to defects such as dislocations and voids at the interface. Ahlawat [14] discovered through molecular dynamics simulations that when perovskite heteroepitaxially grows on commonly used

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oxide substrates, defects such as dislocations and voids are likely to form at the buried interface. During the preparation of perovskite films, the unevenness of crystal grain growth can lead to defects in the bulk phase, affecting the device performance.

Lattice strain is one of the main causes of non-radiative recombination in perovskite films. Du [15] revealed through multiscale studies the direct correlation between lattice strain, defect concentration, and non-radiative recombination. The strain patterns exhibit complex heterogeneity at multiple length scales, indicating that strain is generated during the film growth and crystallization process, serving as the driving force for defect formation.

In the bulk phase of perovskite films, common defects include iodine vacancies, uncoordinated Pb^0 defects, etc. These defects form deep energy levels, acting as non-radiative recombination centers, which reduce the efficiency and stability of the device. Abbas M [16] effectively passivated deep-level defects by introducing 0.03% of methylene diamine (MDA) and cesium (Cs) cations into $FAPbI_3$, resulting in an increase in device efficiency to 24.4%. The method of controlling oxygen vacancies, Lin [17] introduced black phosphorus quantum dots to reduce oxygen vacancies in SnO_{2-x}, suppress the formation of iodine interstitial atoms, stabilize the α-$FAPbI_3$ phase, and improve the device stability. Using surface functionalization treatment, Qiu [18] effectively filled iodine vacancies and suppressed the formation of Pb^0 defects by introducing trimethylsulfonium iodide (TMSI). The treated devices exhibited better charge dynamics and lower energy loss, with an efficiency increase to 24.03%, while also demonstrating excellent air storage and thermal stability (as shown in Figure 2).

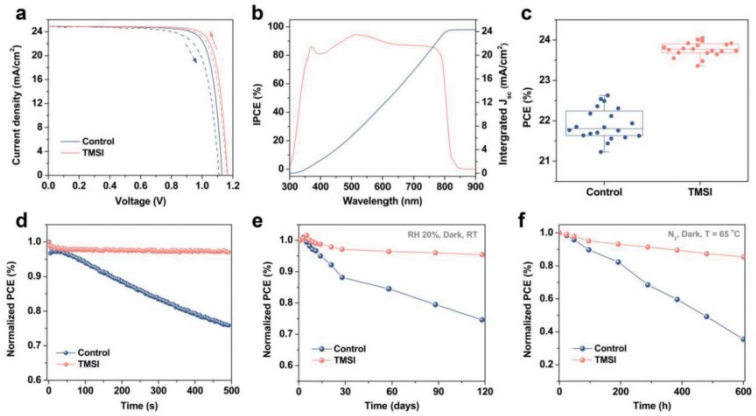

Figure 2: (a) J/V curves of the device in reverse and forward scanning directions (b) EQE spectrum and integrated current density of TMSI devices (c) PCE distribution statistics of two types of devices (data from 20 devices) (d) Evolution of the device's stabilized PCE measured at the maximum power point (e) Evolution of normalized PCE of devices stored in a dark environment at 20% relative humidity and room temperature (f) Evolution of normalized PCE of devices under continuous heating in a nitrogen atmosphere at 65°C (with PTAA replacing Spiro-OMeTAD as the hole transport material)[18]

In recent years, researchers have proposed various innovative strategies in the preparation of perovskite films to address defect issues and enhance the performance and stability of the cells. Ilicheva [19] first achieved bifacial passivation in p-i-n structured perovskite solar cells by introducing fluorinated self-assembled monolayers (SAMs) in both the hole transport layer and electron transport layer. This effectively reduced interface traps and lattice strain. The device efficiency increased to 22.2%, and after 1680 hours of continuous illumination at 65°C, it maintained 88% of its initial performance. By introducing modifiers, Qu [20] designed a dual-function

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passivation method. They coated the perovskite surface with a mixture of 4-tert-butylbenzylammonium iodide and phenylpropylammonium iodide, forming a passivation layer that effectively reduced trap state density, suppressed non-radiative recombination processes, and enhanced device performance. Mahmound Nabil [21] introduced an ADA bilayer passivation layer between the electron and hole transport layers and the perovskite, which reduced the formation of ionic defects and significantly improved stability in high humidity environments. As a result, the cell maintained 80% of its initial efficiency after 4000 minutes under 100% relative humidity and continuous illumination conditions. Using environmentally friendly passivation materials, Wu [22] introduced the natural antioxidant resveratrol to interact with the uncoordinated Pb^{2+} ions in perovskite, achieving effective defect passivation. This strategy increased the device efficiency from 21.62% to 23.44%, and after 1000 hours in a pure oxygen environment, it maintained 88% of its initial efficiency, demonstrating excellent antioxidant properties and environmental stability.

4.2. Energy level alignment optimization

Perovskite solar cells consist of an electron transport layer (ETL), an active layer, and a hole transport layer (HTL). The lowest conduction band energy level of the ETL should be slightly lower than the perovskite active layer to facilitate electron injection. The highest valence band energy level of the HTL should be slightly higher than the perovskite active layer to facilitate hole extraction. This ensures good energy level alignment, reduces energy loss, and improves the short-circuit current density (Jsc), open-circuit voltage (Voc), and fill factor (FF).

Energy level alignment is crucial for the performance of PSCs. Proper energy level alignment reduces the carrier barrier at the interface, facilitating the rapid extraction of electrons and holes. Wang [23] discussed the role of energy level alignment in promoting charge extraction and transport, emphasizing that the synergistic effect of multiple interfaces is key to the success of PSCs. Energy level matching helps reduce non-radiative recombination losses and improves VOC. Ilario Gelmetti [24] studied the impact of different HTMs on VOC and found that changes in energy level positions significantly affect device performance. Energy level matching can also reduce the interface defect density and mitigate degradation caused by ion migration. Wu [25] used multifunctional curcumin molecules to modify the SnO_2/perovskite interface, successfully passivating interface defects and improving energy level alignment. This strategy significantly reduced the interface defect density, enhanced charge carrier transport efficiency, and ultimately achieved a power conversion efficiency of 24.46%, which is approximately 2.4 percentage points higher than the control group, as shown in Figure 3.

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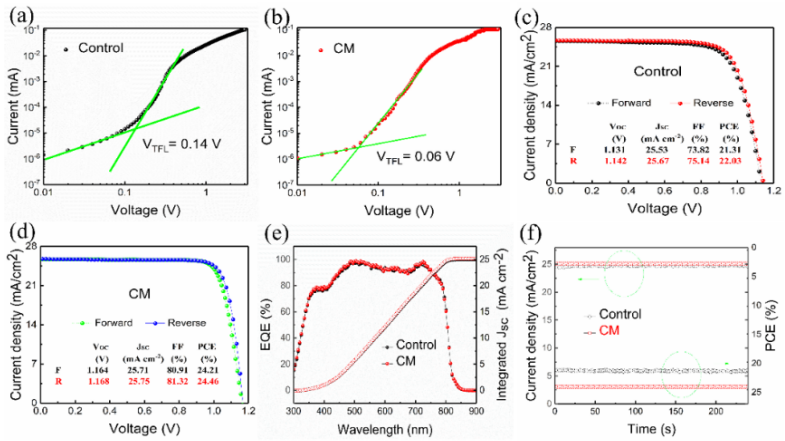

Figure 3: Space charge limited current (SCLC) of devices[25]: (a) ITO/SnO_2/perovskite/PC61BM/Ag (b) ITO/CM-SnO_2/nadte-perovskite/PC61BM/Ag, based on (c) J/V curves of control and (d) CM-SnO_2 devices in different scanning directions, (e) EQE spectra of control and CM-SnO_2-based devices, (f) stable output current density and efficiency at the maximum power point for optimized devices based on control and CM-SnO_2

If the energy levels are mismatched, such as when the lowest conduction band level of the ETL is higher than that of the active layer, it leads to charge accumulation at the interface. This accumulation increases the recombination rate, forming an energy barrier that hinders the injection and extraction of charge carriers. Wang [26] analyzed the mismatch between the quasi-Fermi level splitting (QFLS) and the open-circuit voltage (Voc) in perovskite solar cells. The study showed that when perfect energy level alignment is not achieved in the device, the Voc can be significantly lower than the QFLS, leading to increased charge recombination losses. M.S. Jamal [27] demonstrated through numerical simulations that when the defect density increases from 10^{13} cm^{-3} to 10^{18} cm^{-3}, the power conversion efficiency (PCE) drops from 25% to 5%, all due to the effects of energy level mismatch. Additionally, energy level mismatch also leads to Voc loss and a decline in device long-term stability. If the defect energy levels exceed 0.3 eV above the perovskite conduction band, it significantly impacts efficiency by increasing non-radiative recombination centers.

We found that energy level alignment optimization has a significant effect. Through the use of a bilayer ETL optimization method, Wang [28] demonstrated that by using an In_2O_3/SnO_2 bilayer ETL to optimize energy level alignment, they achieved a power conversion efficiency (PCE) of 23.24% (certified efficiency 22.54%), with a Voc of 1.17 V and a potential loss of only 0.36 V. This represents a significant improvement compared to the single SnO_2 layer, which had a 21.42% efficiency and a 1.13 V Voc, as shown in Figure 4. Using the method of adjusting interface energy levels, Zheng [29] showed that by introducing PCBM to regulate the PVK/HTL interface energy levels, the energy level mismatch was reduced, which accelerated hole extraction and improved electrical performance. Yang [30] introduced different functional groups on the surface of the SnO_2 electron transport layer, using chemical interactions to adjust the interface energy level alignment and improve charge carrier injection performance. The study found that this interface chemical modification strategy, under certain conditions, caused device performance to deviate from the expected trend based on energy level alignment theory, emphasizing the dominant role of interface chemical interactions in the interface optoelectronic performance. Using numerical simulation methods,M.S. Jamal [27] used SCAPS-1D simulations to show that energy level mismatch, along with an increase in defect density, significantly reduces efficiency, providing quantitative data supporting the importance of energy level alignment.

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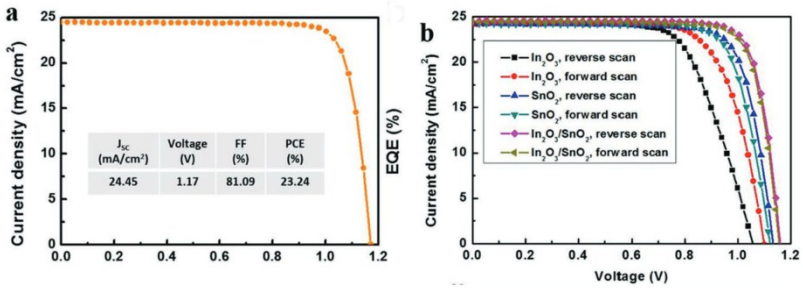

Figure 4: (a) Optimized device based on In_2O_3/SnO_2 ETL. b) J-V curves for reverse and forward scans of devices based on In_2O_3, SnO_2, and In_2O_3/SnO_2[28]

Research on energy level alignment is continuously evolving, especially in the application of inverted PSCs and multi-junction solar cells. The study by Peng [31] emphasized the importance of optimizing the interface dipole moment and orientation in inverted structures to improve device efficiency and stability. By adjusting the interface dipole moment, charge transport can be effectively enhanced, non-radiative recombination reduced, and the power conversion efficiency (PCE) of the device increased to 22.02%, with a PCE of 24.11% achieved in large-area devices. The research by Liu [32] pointed out that by selecting the appropriate charge transport material (CTM), such as SAM-HTM, and optimizing the interface, efficiency and stability can be significantly improved. However, issues related to dynamic energy level changes and long-term stability still need to be addressed. The study by Jose Garcia Cerrillo [33] proposed a method to match the photocurrent of perovskite/organic material tandem modules by adjusting the cell width. Experimental results showed that by adjusting the width of the perovskite and organic modules, excellent short-circuit current matching could be achieved, improving the efficiency of the tandem module to 14.94%.

5. Conclusion and outlook

This article reviews the current research progress of interface modification techniques in enhancing the stability of perovskite solar cells. As a cutting-edge strategy for optimizing the stability of perovskite solar cells, interface modification has opened new avenues for research in this field. However, its underlying mechanisms and influencing factors still involve many critical scientific questions that need to be addressed. In the process of moving toward industrial application, from laboratory breakthroughs to large-scale commercial production, challenges such as material system optimization, process compatibility, and cost control remain substantial. Continuous systematic research and technological innovation are required to overcome these hurdles.

Future research could focus on developing self-healing interface materials that can repair micro-damage caused by external environmental influences, thereby continuously maintaining the stability of the battery's performance. Additionally, by leveraging advanced theoretical calculation methods, further insights into the microscopic mechanisms of interface modification can be gained, providing valuable guidance for the design and optimization of interface materials.

References

[1] *Habibi M , Zabihi F , Ahmadian-Yazdi M R ,et al.Progress in emerging solution-processed thin film solar cells – Part II: Perovskite solar cells[J].Renewable and Sustainable Energy Reviews, 2016, 62(sep.):1012-1031.*

[2] *Sheng M J ,He Z L ,Chen Y ,et al.Research progress on packaging technology of perovskite solar cells[J]. Semiconductor Technology,2024,49(09):785-793.*

[3] *Jin S L ,Shou C H ,Huang M J ,et al.Progress in Stability Research of Perovskite Solar Cells and Industrialization Trend of Modules[J].Materials Reports, 2023, 37(5):1-13.*

DOI: 10.54254/2755-2721/2025.GL25563

[4] Song J H . Research progress on the preparation of large-area modules for perovskite solar cells[J].Petrochemical Technology,2023,52(01):124-130.
[5] Sun H , Deng J , Qiu L ,.Recent progress in solar cells based on one-dimensional nanomaterials[J].Energy & Environmental Science, 2015, 8(4):1139-1159.
[6] Chueh C C , Li C Z , Jen K Y .Recent progress and perspective in solution-processed Interfacial materials for efficient and stable polymer and organometal perovskite solar cells[J].Energy & Environmental Science, 2015, 8(4):1160-1189.
[7] Liu Z Q . Research on the Performance of n-i-p Structure Perovskite Solar Cells Based on Interface Modification and Spectral Response Control[D].Jilin University,2024.
[8] Tan, S., Huang, T., Yavuz, I. et al. Stability-limiting heterointerfaces of perovskite photovoltaics. Nature 605, 268–273 (2022).
[9] Chen Z J .Research on high-performance perovskite solar cells based on interface modification[D].University of Chinese Academy of Sciences (Institute of Physics, Chinese Academy of Sciences),2024.
[10] Ardimas, Pakornchote, T., Sukmas, W. et al. Phase transformations and vibrational properties of hybrid organic–inorganic perovskite $MAPbI_3$ bulk at high pressure. Sci Rep 13, 16854 (2023).
[11] Niu G , Guo X , Wang L .Review of recent progress in chemical stability of perovskite solar cells[J].Journal of Materials Chemistry A, 2015, 3(17):8970-8980.
[12] Hong W T , Risch M , Stoerzinger K A ,et al.Toward the rational design of non-precious transition metal oxides for oxygen electrocatalysis[J].Energy & Environmental Science, 2015, 8(5):1404-1427.
[13] Kovalenko M V , Protesescu L , Bodnarchuk M I .Properties and potential optoelectronic applications of lead halide perovskite nanocrystals[J].Science, 2017, 358(6364):745.
[14] Ahlawat P , Clementi C , Musil F ,et al.Lattice matched heterogeneous nucleation eliminate defective buried interface in halide perovskites[J]. 2024.
[15] Tian Du , Filipe Richheimer , Kyle Frohna ,et al.Overcoming Nanoscale Inhomogeneities in Thin-Film Perovskites via Exceptional Post-annealing Grain Growth for Enhanced Photodetection[J].Nano Lett, 2022, 22(3):979-988.
[16] Abbas M , Xu X , Rauf M ,et al.A Comprehensive Review on Defects-Induced Voltage Losses and Strategies toward Highly Efficient and Stable Perovskite Solar Cells[J].Photonics, 2024, 11(1).
[17] Lin H Y , Jiang Z , Liu S C ,et al.Overcoming Microstructural Defects at the Buried Interface of Formamidinium-Based Perovskite Solar Cells[J].ACS Applied Materials & Interfaces, 2024, 16(36):10.
[18] Qiu F , Liu Q , Liu Y ,et al.Managing Interface Defects via Mixed-Salt Passivation toward Efficient and Stable Perovskite Solar Cells[J].Small, 2023, 19(50).
[19] Ilicheva E A , Sukhorukova P K , Luchnikov L O ,et al.Double-side Integration of the Fluorinated Self-Assembling Monolayers for Enhanced Stability of Inverted Perovskite Solar Cells[J]. 2024.
[20] Qu Z , Zhao Y , Ma F ,et al.Enhanced charge carrier transport and defects mitigation of passivation layer for efficient perovskite solar cells[J].Nature Communications, 2024, 15(1).
[21] Nabil M , Contreras-Bernal L , Moreno-Martinez G P ,et al.Boosting Perovskite Solar Cell Stability: Dual Protection with Ultrathin Plasma Polymer Passivation Layers[J]. 2024.
[22] Wu X , Bi J , Cui G ,et al.An eco-friendly passivation strategy of resveratrol for highly efficient and antioxidative perovskite solar cells[J]. 2024.
[23] Wang S , Sakurai T , Wen W ,et al.Energy Level Alignment at Interfaces in Metal Halide Perovskite Solar Cells (vol 5, 1800260, 2018)[J].Advanced materials interfaces, 2020(8):7.
[24] Ilario Gelmetti ,Núria F. Montcada , Ana Pérez-Rodríguez ,et al. Energy alignment and recombination in perovskite solar cells: weighted influence on the open circuit voltage[J].Energy & Environment Science, 2019, 80(4):1-2.
[25] Wu X , Bi J , Cu G ,et al.Highly Efficient and Stable Perovskite Solar Cells via MultiFunctional Curcumin Modified Buried Interface[J]. 2024.
[26] Jonathan Warby , Sahil Shah ,Jarla Thiesbrummel,et al.Mismatch of Quasi–Fermi Level Splitting and Voc in Perovskite Solar Cells[J].Advanced Energy Materials, 2023.
[27] Jamal, M. S.Shahahmadi, S. A.Wadi ,et al.Effect of defect density and energy level mismatch on the performance of perovskite solar cells by numerical simulation[J].Optik: Zeitschrift fur Licht- und Elektronenoptik: = Journal for Light-and Electronoptic, 2019, 182.
[28] Wang P , Li R , Chen B ,et al.Gradient Energy Alignment Engineering for Planar Perovskite Solar Cells with Efficiency Over 23%[J].Advanced Materials, 2020.
[29] Zheng Q , Zou Y , Wang Y ,et al.Regulation of interface energy level alignment of perovskite solar cells by fullerene derivative of PCBM[J].Chemical Engineering Journal, 2024, 498(000).
[30] Yang, C., Hu, W., Liu, J. et al. Achievements, challenges, and future prospects for industrialization of perovskite solar cells[C].Light Sci Appl 13, 227 (2024).
[31] Peng Y , Chen Y , Zhou J ,et al.Enlarging moment and regulating orientation of buried interfacial dipole for efficient inverted perovskite solar cells[J].Nature Communications[2025-04-18].

DOI: 10.54254/2755-2721/2025.GL25563

[32] Liu S , Biju V P P , Qi W L Z .Recent progress in the development of high-efficiency inverted perovskite solar cells[J].NPG Asia Materials, 2023, 15(1).

[33] García Cerrillo, José, Distler A , Matteocci F ,et al.Matching the Photocurrent of 2-Terminal Mechanically-Stacked Perovskite/Organic Tandem Solar Modules by Varying the Cell Width[J].Solar RRL, 2024, 8(3).