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1. Non-fused ring acceptors for organic solar cells

Review [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Yang M, Wei W, Zhou X, Wang Z, Duan C. Non-fused ring acceptors for organic solar cells. *Energy Mater* 2021;1:100008. <http://dx.doi.org/10.20517/energymater.2021.08>

Abstract

Organic solar cells (OSCs) have experienced rapid development and achieved significant breakthroughs in power conversion efficiencies owing to the emergence of non-fullerene acceptors (NFAs) with ladder-type multiple fused ring structures. However, the high synthetic complexity and production cost of multiple fused ring NFAs hinder the commercial prospects of OSCs. In this context, the development of non-fused ring acceptors (NFRAs) with simple structures and facile synthesis has been proposed. In this mini review, we summarize the important progress in this field spanning from molecular design strategies to structure-performance relationships. Ultimately, with the aim of realizing the practical application of NFRAs in OSCs, we discuss the current challenges and future directions in terms of achieving high performance and low synthetic complexity simultaneously. These discussions provide valuable insights into the development of new NFRAs.

Keywords

Organic solar cells, non-fullerene acceptors, non-fused ring acceptors, low cost, device performance

2. Recent developments in advanced anode materials for lithium-ion batteries

Review [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Chang H, Wu YR, Han X, Yi TF. Recent developments in advanced anode materials for lithium-ion batteries. *Energy Mater* 2021;1:100003. <http://dx.doi.org/10.20517/energymater.2021.02>

Abstract

The rapid expansion of electric vehicles and mobile electronic devices is the main driver for the improvement of advanced high-performance lithium-ion batteries (LIBs). The electrochemical performance of LIBs depends on the specific capacity, rate performance and cycle stability of the electrode materials. In terms of the enhancement of LIB performance, the improvement of the anode material is significant compared with the cathode material. There are still some challenges in producing an industrial anode material that is superior to commercial graphite. Based on the different electrochemical reaction mechanisms of anode materials for LIBs during charge and discharge, the advantages/disadvantages and electrochemical reaction mechanisms of intercalation-, conversion- and alloying-type anode materials are summarized in detail here. The methods and strategies for improving the electrochemical performance of different types of anode materials are described in detail. Finally, challenges for the future development of LIBs are also considered. This review offers a meaningful reference for the construction and performance optimization of anode materials for LIBs.

Keywords: Anode, lithium-ion battery, intercalation, conversion, alloying

3. Automated machine learning structure-composition-property relationships of perovskite materials for energy conversion and storage

Article [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Deng Q, Lin B. Automated machine learning structure-composition-property relationships of perovskite materials for energy

conversion and storage. *Energy Mater* 2021;1:100006.
<http://dx.doi.org/10.20517/energymater.2021.10>

Abstract: Perovskite materials are central to the fields of energy conversion and storage, especially for fuel cells. However, they are challenged by overcomplexity, coupled with a strong desire for new materials discovery at high speed and high precision. Herein, we propose a new approach involving a combination of extreme feature engineering and automated machine learning to adaptively learn the structure-composition-property relationships of perovskite oxide materials for energy conversion and storage. Structure-composition-property relationships between stability and other features of perovskites are investigated. Extreme feature engineering is used to construct a great quantity of fresh descriptors, and a crucial subset of 23 descriptors is acquired by sequential forward selection algorithm. The best descriptor $(\ln(1 + |r_A|)r_B^{-1}c^2\alpha^{-1})^{-1}$ for stability of perovskites is determined with linear regression. The results demonstrate a high-efficient and non-priori-knowledge investigation of structure-composition-property relationships for perovskite materials, providing a new road to discover advanced energy materials.

Keywords: Perovskites, structure-composition-property relationships, stability, descriptors, automated machine learning

4. Enhancing cycle life of nickel-rich $\text{LiNi}_{0.9}\text{Co}_{0.05}\text{Mn}_{0.05}\text{O}_2$ via a highly fluorinated electrolyte additive – pentafluoropyridine

Article [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Zhang X, Liu G, Zhou K, Jiao T, Zou Y, Wu Q, Chen X, Yang Y, Zheng J. Enhancing cycle life of nickel-rich $\text{LiNi}_{0.9}\text{Co}_{0.05}\text{Mn}_{0.05}\text{O}_2$ via a highly fluorinated electrolyte additive-pentafluoropyridine. *Energy Mater* 2021;1:100005. <http://dx.doi.org/10.20517/energymater.2021.07>

Abstract

A highly fluorinated additive, pentafluoropyridine (PFP), is used here to enhance the interfacial stability of the Ni-rich $\text{LiNi}_{0.9}\text{Co}_{0.05}\text{Mn}_{0.05}\text{O}_2$ (NCM90) cathode at a cut-off voltage of 4.3 V vs. Li/Li^+ at 30 °C. The capacity retention of the NCM90||Li cell is obviously improved from 72.3% to 80.3% after 200 cycles at 1C (1C = 180 mA g⁻¹) when 0.2% PFP is introduced into the baseline electrolyte (1 mol L⁻¹ LiPF₆ in ethylene carbonate/diethyl carbonate). The improvement in electrochemical performance could be attributed to the formation of a compact and uniform cathode electrolyte interphase (CEI) layer enriched with F-containing polypyridine moieties and LiF species on the NCM90 particles. This CEI prevents side reactions between the electrode and electrolyte and hinders the corrosion of the cathode caused by HF attack. In addition, the formation of internal particle cracks is somewhat suppressed by the robust CEI, thus prohibiting the irreversible phase transformation and better maintaining the superior lithium-ion diffusion kinetics.

Keywords: Pentafluoropyridine, electrolyte additive, cathode electrolyte interphase, $\text{LiNi}_{0.9}\text{Co}_{0.05}\text{Mn}_{0.05}\text{O}_2$, lithium-ion batteries

5. Thin-walled hollow fibers for flexible high energy density fiber-shaped supercapacitors

Communication [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: He C, Cheng J, Liu Y, Zhang X, Wang B. Thin-walled hollow fibers for flexible high energy density fiber-shaped supercapacitors. *Energy Mater* 2021;1:100010. <http://dx.doi.org/10.20517/energymater.2021.14>

Abstract

Fiber-shaped supercapacitors, which occupy minimal volume and possess remarkable flexibility, are particularly promising candidates for next-generation smart wearable devices. However, the state-of-the-art energy density and mechanical properties of fiber-shaped electrodes are far from satisfactory. Herein, hollow poly(3,4-ethylenedioxythiophene): polystyrene sulfonate thin-walled fibers (HPFs) are continuously prepared by coaxial wet-spinning. These HPFs combine a simple and high continuous preparation with high electrochemical performance and flexibility, owing to their hollow nature, small diameter (125 μm) and thin wall structure (8 μm). As a result, the HPFs display a specific areal capacitance of 115.2 mF cm^{-2} at a current density of 0.3 mA cm^{-2} with a high energy density of 9 $\mu\text{Wh cm}^{-2}$ at a power density of 0.112 mW cm^{-2} . Furthermore, the HPFs maintain 81% of the initial capacitance after 10,000 cycles with $\sim 100\%$ Coulombic efficiency. More importantly, the specific capacitance is almost completely maintained after bending 3000 times at 180° .

Keywords: Fiber-shaped supercapacitors, PEDOT:PSS, energy density, flexible

6. Recent research on emerging organic electrode materials for energy storage

Perspective [Full-Text PDF RIS](#)

Copy here to cite this article: Huang T, Long M, Xiao J, Liu H, Wang G. Recent research on emerging organic electrode materials for energy storage. *Energy Mater* 2021;1:100009. <http://dx.doi.org/10.20517/energymater.2021.09>

Abstract

Due to the growth of the demand for rechargeable batteries in intelligent terminals, electric vehicles, energy storage, and other markets, electrode materials, as the essential of batteries, have attracted tremendous attention. The research of emerging organic electrode materials in batteries has been boosted recently to their advantages of low cost, environmental friendliness, biodegradability, and designability. This manuscript highlights and classifies several recent studies on organic electrode materials and lists their potential applications in various battery systems. Finally, the challenge and perspective of organic electrode materials are also summarized.

Keywords: Organic electrode materials, batteries, energy storage, low-cost electrode materials, environmentally friendly materials

7. Electrolyte solvation structure as a stabilization mechanism for electrodes

Perspective [Full-Text PDF RIS](#)

Copy here to cite this article: Zhang L, Chen Y. Electrolyte solvation structure as a stabilization mechanism for electrodes. *Energy Mater* 2021;1:100004. <http://dx.doi.org/10.20517/energymater.2021.04>

Abstract

Rechargeable batteries with high capacity, power and safety are urgently required for current and future technological demands. The solid electrolyte interphase (SEI) layer has a dominant impact on battery cyclability and the solvate is the key factor that determines the SEI layer. In this perspective, we first review the recent advances in understanding the influences of electrolyte composition on the solvation chemistry and SEI layer. The solvation structure of electrolytes seems to be the root cause of the stability of electrodes during cell cycling. We then discuss the strategy to manipulate the solvation chemistry by adjusting the compositions of the electrolytes, including the solvent, salt, concentration and additive. Finally, we concisely discuss the challenges in characterizing the structure of the solvates at the electrode|electrolyte interface. This review refreshes our current understanding of the key factors for stable

electrode|electrolyte interfaces in the pursuit of high-performance battery systems.

Keywords: Electrolytes, solvation structure, electrode|electrolyte interface, mechanistic study

8. A nanoscale perspective on solid oxide and semiconductor membrane fuel cells: materials and technology

Perspective [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Zhu B, Mi Y, Xia C, Wang B, Kim JS, Lund P, Li T. A nanoscale perspective on solid oxide and semiconductor membrane fuel cells: materials and technology. *Energy Mater* 2021;1:100002. <http://dx.doi.org/10.20517/energymater.2021.03>

Abstract

Fuel cells could play an important role in the ongoing energy transition by providing clean and efficient energy conversion. Although the solid oxide fuel cell (SOFC) technology is a potential alternative for large-scale applications, its commercialization is limited by its electrolyte materials and has not yet been realized. Progress on new functional semiconductor-ionic materials (SIMs) and the fundamentals of SOFCs will provide new paths for their research and development. Herein, we discuss the nanoscale electrochemistry phenomena of SIMs in the context of new concepts for advanced SOFCs. A traditional SOFC consists of a three-layer anode/electrolyte/cathode structure, where the physically separated electrolyte layer is indispensable for ion transport to support the redox reaction and prevent the occurrence of short circuiting. A novel nano-SOFC concept is proposed to replace the traditional electrolyte by a SIM or semiconductor membrane and it can deliver superior performance, even at a lower temperature range (< 500 °C). The scientific basis and prospects of this new technological approach are presented and discussed.

Keywords: Semiconductor-ionic materials, nano-fuel cell, semiconductor membrane fuel cells, triple-charge conduction

9. Advanced low-temperature solid oxide fuel cells based on a built-in electric field

Research Highlight [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Lu Y, Zhu B, Shi J, Yun S. Advanced low-temperature solid oxide fuel cells based on a built-in electric field. *Energy Mater* 2021;1:100007. <http://dx.doi.org/10.20517/energymater.2021.06>

10. Welcome to the journal of Energy Materials: a new scientific journal

Editorial [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Wu Y, Zhu B. Welcome to the journal of *Energy Materials*: a new scientific journal. *Energy Mater* 2021;1:100001. <http://dx.doi.org/10.20517/energymater.2021.01>

11. Modulating the lithiophilicity at electrode/electrolyte interface for high-energy Li-metal batteries

Review [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Li CC, Zhang XS, Zhu YH, Zhang Y, Xin S, Wan LJ, Guo YG. Modulating the lithiophilicity at electrode/electrolyte interface for high-energy Li-metal batteries. *Energy Mater* 2021;1:100017. <http://dx.doi.org/10.20517/energymater.2021.21>

Abstract

Lithium-metal anodes show significant promise for the construction of high-energy rechargeable batteries due to their high theoretical capacity (3860 mAh g⁻¹) and low redox potential (-3.04 V vs. a standard hydrogen electrode). When Li metal is used with conventional liquid and solid electrolytes, the poor lithiophilicity of the electrolyte results in an unfavorable parasitic reaction and uneven distribution of Li⁺ flux at the electrode/electrolyte interface. These issues result in limited cycle life and dendrite problems associated with the Li-metal anode that can lead to rapid performance fade, failure and even safety risks of the battery. The lithiophilicity at the anode/electrolyte interface is important for the stable and safe operation of rechargeable Li-metal batteries. In this review, several factors that affect the lithiophilicity of electrolytes are discussed, including surface energy, roughness and chemical interactions. The existing problems and the strategies for improving the lithiophilicity of different electrolytes are also discussed. This review helps to shed light on the understanding of interfacial chemistry vs. Li metal of various electrolytes and guide interfacial engineering towards the practical realization of high-energy rechargeable batteries.

Keywords: Rechargeable batteries, Li-metal anodes, lithiophilicity, electrode/electrolyte interface

12. A review of the energy storage aspects of chemical elements for lithium-ion based batteries

Review [Full-Text PDF RIS](#)

Copy here to cite this article: Bashir T, Ismail SA, Song Y, Irfan RM, Yang S, Zhou S, Zhao J, Gao L. A review of the energy storage aspects of chemical elements for lithium-ion based batteries. *Energy Mater* 2021;1:100019. <http://dx.doi.org/10.20517/energymater.2021.20>

Abstract

Energy storage devices such as batteries hold great importance for society, owing to their high energy density, environmental benignity and low cost. However, critical issues related to their performance and safety still need to be resolved. The periodic table of elements is pivotal to chemistry, physics, biology and engineering and represents a remarkable scientific breakthrough that sheds light on the fundamental laws of nature. Here, we provide an overview of the role of the most prominent elements, including s-block, p-block, transition and inner-transition metals, as electrode materials for lithium-ion battery systems regarding their perspective applications and fundamental properties. We also outline hybrid materials, such as MXenes, transition metal oxides, alloys and graphene oxide. Finally, the challenges and prospects of each element and their derivatives and hybrids for future battery systems are discussed, which may provide guidance towards green, low-cost, versatile and sustainable energy storage devices.

Keywords: Lithium-ion based batteries, specific capacity, cathode materials, anode materials

13. Recent advances in anion-derived SEIs for fast-charging and stable lithium batteries

Review [Full-Text PDF RIS](#)

Copy here to cite this article: Xiao Y, Xu R, Xu L, Ding JF, Huang JQ. Recent advances in anion-derived SEIs for fast-charging and stable lithium batteries. *Energy Mater* 2021;1:100013. <http://dx.doi.org/10.20517/energymater.2021.17>

Abstract

The construction of stable and reliable electrode interfaces is one of the key scientific issues widely encountered by the battery community. An anion-derived solid electrolyte interphase (SEI) has been recently reported to outperform the traditional solvent-rich SEI in inhibiting side reactions, motivating ion transport and regulating electrode reactions in working Li batteries. Here, we first explicitly introduce the fundamental characteristics of anion-derived SEIs and then concisely present novel developments in electrolyte chemistry involving highly concentrated, localized highly concentrated and weakly solvating electrolytes, which facilitate the formation of anion-derived SEIs on anodes. The critical significance of these SEIs for building fast-charging and stable Li batteries is particularly highlighted. Finally, we outline the future challenges of designing Li metal interfaces to further enhance the cycling reversibility and lifespan of working batteries.

Keywords: Lithium metal anode, solid electrolyte interphases, highly concentrated electrolytes, weakly solvating electrolytes, anion-derived SEIs

14. Critical advances in re-engineering the cathode-electrolyte interface in alkali metal-oxygen batteries

Review [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Peng X, Wang C, Liu Y, Fang W, Zhu Y, Fu L, Ye J, Liu L, Wu Y. Critical advances in re-engineering the cathode-electrolyte interface in alkali metal-oxygen batteries. *Energy Mater* 2021;1:100011. <http://dx.doi.org/10.20517/energymater.2021.15>

Abstract

Due to its porous structure and special reaction characteristics, the cathode-electrolyte interface in alkali metal-oxygen batteries (AMOBs) has a substantial impact on their electrochemical performance. However, in traditional sandwich-like battery structures, the reaction position in the cathode is restricted to the finite planar cathode-electrolyte interface, leading to AMOBs with limited performance. As a result, a growing number of research studies have sought to re-engineer the cathode-electrolyte interface to enhance the performance of AMOBs. This review summarizes the latest methods published in recent years in this field and compares a variety of different techniques. Regardless of the method used, the ultimate goal is to expand the cathode-electrolyte interface to create more triple reaction activity sites for ions, oxygen and electrons. The most important performance improvement of AMOBs is reflected by the increased specific capacity. Additional challenges valuable for the further development of alkali metal-oxygen batteries are also discussed.

Keywords: Alkali metal-oxygen batteries, cathode-electrolyte interface, rational design, surface engineering, electrolytes

15. Deuterium labelling by electrochemical splitting of heavy water

Mini Review [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Liu J, Chen Z, Koh MJ, Loh KP. Deuterium labelling by electrochemical splitting of heavy water. *Energy Mater* 2021;1:100016. <http://dx.doi.org/10.20517/energymater.2021.19>

Abstract

Deuterium incorporation is crucial in organic synthesis and has wide applications in the pharmaceutical industry. State-of-the-art H/D isotope exchange and chemical defunctionalization for deuterium incorporation suffer from significant drawbacks, including expensive deuterium sources, low deuteration efficiency and poor selectivity. In this perspective, we highlight an alternative pathway for forming C-D

bonds by electrocatalytic heavy water splitting (D₂O) under mild conditions. In addition, the intrinsic mechanism and examples of the synthesis of deuterated pharmaceuticals are discussed in detail. Finally, we present the challenges facing this field and provide an overall perspective on future research directions.

Keywords: Deuteration, water splitting, electrocatalysis, pharmaceuticals, H/D exchange

16. Constructing 1D/2D interwoven carbonous matrix to enable high-efficiency sulfur immobilization in Li-S battery

Article [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Ruan J, Sun H, Song Y, Pang Y, Yang J, Sun D, Zheng S. Constructing 1D/2D interwoven carbonous matrix to enable high-efficiency sulfur immobilization in Li-S battery. *Energy Mater* 2021;1:100018. <http://dx.doi.org/10.20517/energymater.2021.22>

Abstract

The lithium-sulfur battery is currently considered to be a promising candidate for next-generation energy storage devices. However, its commercial application is severely restricted by rapid capacity decay mainly arising from unavoidable dissolution of intermediate lithium polysulfide of the S-based cathodes. Herein, multifunctional stripped grapheme-carbon nanotubes (SG-CNT) with 1D/2D interwoven and hierarchical pore structure as a promising host to stabilize S was constructed by cheaper raw materials and a facile strategy. Based on comprehensive analysis, the interwoven network and hierarchical pores along with abundant oxidative functional groups in matrix provided large contact area with S, short transport pathway for electrons/Li-ions, sufficient space to accommodate volumetric change, and superior confinement ability for S/polysulfides, thus resulting in effectively stabilizing the S cathode with high S loading and increasing its utilization. Therefore, the S@SG-CNT cathodes exhibited a high reversible capacity of 1227 mAh g⁻¹ at 0.1 A g⁻¹, excellent cyclability with a capacity of 773 mAh g⁻¹ after 500 cycles at 0.2 A g⁻¹, and ultra-long cycling performance with capacity decay less than 0.01% per cycle at 2 A g⁻¹. This facile strategy and unique construction of superior performance cathode provide a new avenue for next commercial application.

Keywords: Graphene, carbon, hierarchical pores, cathode, Li-S battery

17. Stable and efficient seawater splitting on a porous phosphate-intercalated NiFe (oxy)hydroxide@NiMoO₄ core-shell micropillar electrode

Article [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Yang C, Gao N, Wang X, Lu J, Cao L, Li Y, Liang HP. Stable and efficient seawater splitting on a porous phosphate-intercalated NiFe (oxy)hydroxide@NiMoO₄ core-shell micropillar electrode. *Energy Mater* 2021;1:100015. <http://dx.doi.org/10.20517/energymater.2021.16>

Abstract

Seawater splitting powered by solar or wind sources is a significant renewable energy storage technology for the production of green hydrogen energy. However, both the chlorine evolution reaction and chloride corrosion are intractable issues in seawater splitting. Here, a porous electrode based on a phosphate-intercalated NiFe (oxy)hydroxide shell coated on a nickel molybdate (NiMoO₄) micropillar core (denoted as P-NiFe@NiMoO₄) is synthesized through an electrochemical oxidation strategy. During the electrochemical oxidation process, the etching of MoO₂ promotes the reconstruction of NiFe (oxy)hydroxide and the formation of porous structures in

an alkaline solution. The optimized P-NiFe@NiMoO₄ electrocatalysts afford a low overpotential of 258 mV at a current density of 100 mA/cm² in alkaline seawater. By pairing the anode with a cathode of as-synthesized P-NiMoO, the electrolyzer presents a low voltage of 1.63 V at 100 mA/cm² in alkaline seawater with excellent stability. Moreover, the remarkable stability of the anode seems to be attributed to the in-situ phosphate formed during the electrochemical oxidation process to passivate chloride corrosion.

Keywords: NiFe(oxy)hydroxide, NiMoO₄ micropillars, oxygen evolution reaction, seawater splitting

18. Hierarchical Ni- and Co-based oxynitride nanoarrays with superior lithiophilicity for high-performance lithium metal anodes

Article [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Wang Y, Xu H, Zhong J, Wang T, Lu B, Zhu J, Duan X. Hierarchical Ni- and Co-based oxynitride nanoarrays with superior lithiophilicity for high-performance lithium metal anodes. *Energy Mater* 2021;1:100012. <http://dx.doi.org/10.20517/energymater.2021.18>

Abstract

Lithium metal has emerged as the most prospective candidate for the realization of improved battery systems. However, notorious Li dendrite formation and the huge volume effect during cycling critically impair the further practical deployment of Li metal batteries. Herein, we propose hierarchical Ni- and Co-based oxynitride (NiCoO₂/CoO/Ni₃N) nanoarrays with superior lithiophilicity on a three-dimensional nickel foam (NiCoON/NF) as a host for highly stable Li metal anodes. The uniform nitrogen-infused nanorod-on-nanosheet arrays present improved electrical conductivity and an increased concentration of active sites with oxygen vacancies to enhance the surface lithiophilicity, which effectively facilitates homogeneous Li nucleation/growth. Moreover, the hyperbranched structure can induce a homogeneous distribution of Li-ion flux, owing to the enlarged surface area, thereby providing sufficient space to store deposited lithium and relieve the volume expansion. Consequently, the NiCoON/NF host delivers a high Coulombic efficiency (98.4% over 600 cycles) at 1 mA cm⁻² and an ultralong lifespan (> 2000 h) under a high capacity of 3 mAh cm⁻². Remarkably, a Li@NiCoON/NF-LiFePO₄ full battery also reveals impressive electrochemical performance. This work demonstrates new insights into safe rechargeable Li metal batteries.

Keywords: Hyperbranched structure, lithiophilic oxynitride nanoarrays, high Coulombic efficiency, super cycling stability, lithium metal anodes

19. Homojunction perovskite solar cells: opportunities and challenges

Perspective [Full-Text](#) [PDF](#) [RIS](#)

Copy here to cite this article: Cui P, Qu S, Zhang Q, Liu B, Yan L, Du S, Wang X, Huang H, Ji J, Li M. Homojunction perovskite solar cells: opportunities and challenges. *Energy Mater* 2021;1:100014. <http://dx.doi.org/10.20517/energymater.2021.13>

Abstract

Organometallic halide perovskites have rapidly become promising materials as a result of their outstanding properties in high-efficiency and low-cost next-generation solar cells. Perovskite materials can be adjusted to be p- or n-type by defect engineering through, for example, the self-doping method by controlling the precursor compositions and process conditions. Recently, a p-type perovskite/n-type perovskite

homojunction has been proposed and constructed, which provides a possibility for the design of a novel type of perovskite solar cell (PSC). Following a brief overview of the physical fundamentals of perovskite homojunctions, a detailed discussion of the promising progress of recently reported homojunction PSCs is presented here, including theoretical simulations, extrinsic and interfacial doping and graded structures. Furthermore, the opportunities regarding higher doping concentrations, simpler device architectures, ion migration inhibition and device stability are discussed. Finally, an outlook that offers insights into the future development of highly efficient and stable homojunction PSCs is provided.

Keywords: Perovskite homojunctions, p-n junctions, electrical doping, solar cells