




Perovskites march on: a themed collection

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With the depletion of fossil energy and the intensification of environmental pollution, the development of renewable clean energy has become an urgent demand for sustainable social development. As an emerging class of optoelectronic semiconductor materials, organic-inorganic hybrid perovskites have gained widespread attention from researchers around the world.

The first perovskite solar cell was reported by Miyasaka and coworkers in 2009,¹ representing a breakthrough in photovoltaics research. Because of their intriguing optoelectronic properties, such as light absorption, carrier transmission, and luminous performance, research on perovskite solar cells has been increasing rapidly. In 2012, the groups of Grätzel and Park demonstrated solid-state perovskite photovoltaic devices with an efficiency of 9.7% that overcame the poor stability of the materials in liquid-based solar cells.² Meanwhile, Snaith and coworkers from the University of Oxford replaced mesoporous Al₂O₃ with TiO₂ and introduced an organic hole-transport material, enabling a higher device efficiency of 10.9%.³ Since then, organic-inorganic hybrid perovskites have become the front runners among emerging photovoltaic materials.

Recently, the fabrication of perovskite nanomaterials and their mechanistic studies have attracted extensive attention.⁴ For instance, significant efforts have been devoted to developing new hole-transport materials, such as indolo [3,2-*b*]indole,⁵ quinoxaline^{6,7} and fluoranthene-based materials;⁸ Sellinger and coworkers from the National Renewable Energy Laboratory focused on doping strategies for organic small molecule hole-transport layers (ionic liquids, metal-based salts, oxidized radical cation salts, TCNQ derivatives) in perovskite solar cells;⁹ amino-functionalized conjugated polymer electron transport layers could enhance the UV-photostability of planar heterojunctions, which was essential for the commercialization of high-performance and stable flexible perovskite solar cells;¹⁰ Sugimoto and Segawa predicted that the surface modification of metal halide perovskites using graphene could prevent carrier trapping, which would improve the energy conversion efficiencies of perovskite solar cells.¹¹

Due to their quantum confinement or strong anisotropy, nanomaterials exhibit excellent electrical and optical properties. The groups of Xiong from Nanyang Technological University and Irvine from the University of St Andrews discussed the different synthesis approaches and growth mechanisms, as well as various applications, of metal halide perovskite

nanomaterials and nanoporous perovskite metal oxides, respectively;^{12,13} the synthesis of one-dimensional organic-inorganic hybrid perovskite micro/nanostructures, reported by Yan's group, efficiently enhanced the water stability and luminescence properties, thus extending their applications to sensing and photonic communication micro-devices;¹⁴ Wu's group suggested that tetracenes could drive single and even multi-electron photochemical reactions;¹⁵ Moser and coworkers investigated the charge transfer dynamics at the surface of nanoparticles;¹⁶ Nag's and Mandal's group discovered that colloidal thallium halide nanocrystals possessed high effective carrier mobility, long diffusion length and reasonably high luminescence.¹⁷

Perovskites are now considered as the most promising optoelectronic materials for future applications. We hope this themed collection will showcase the latest developments in perovskites and shed some light on future research trends for their applications.

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