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Welcoming the First Decade of Perovskite Solar Cells

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The swift emergence of perovskite solar cells (PSCs) is a "miracle" development in the history of photovoltaics. Since Miyasaka and co-workers (Toin University of Yokohama, Japan) reported the first use of halide perovskites (HPs) in solar cells in 2009, the past ten years have witnessed a skyrocketing increase in power conversion efficiency (PCE) to 24.2% for single-junction PSCs and 28.0% for Si-perovskite tandem solar cells. Meanwhile, the PSC stability, the Achilles heel of this technology, has been enhanced substantially. While the early versions of PSCs were stable just for a few days, the state-of-the-art PSCs have now demonstrated more than 10,000 hours of operational stability and a few thousand hours of outdoor stability, advancing the practical deployment of PSCs significantly. Such impressive progress in the PCE and stability of PSCs has been not only attributed to the creative technological innovation in device structures, perovskite processing, charge-transport-layer engineering, interface modification, etc., but also related to the fascinating understanding of fundamental sciences in HP materials that include crystal structure, defect chemistry, crystallization, photophysics, and light-matter interaction.

In this context, an important, fruitful discussion on both fundamental and technological progresses in HPs, PSCs, and perovskite optoelectronics took place at the perovskite-focused 'twin'-symposia of ET04: Perovskite Solar Cells — Challenges and Opportunities and ET05: Fundamental Aspects of Halide Perovskite (Opto)electronics and Beyond at the 2018 Materials Research Society (MRS) Fall Meeting (Nov. 26–30, 2018, Boston, MA, USA). While a summary on this discussion has been reported, here we introduce a collection of papers from the leading scientists involved in the "twin" symposia, which shows their most recent research progress and critical opinions on PSCs. We have also invited worldwide contributions from other outstanding perovskite research groups from China, United States, Germany, Sweden, Switzerland, Israel, Brazil, etc. All these contributions constitute this special issue in Solar RRL titled Perovskite Photovoltaics and Optoelectronics, which we are delighted to put together for the 10th anniversary celebration of PSC invention.

This special issue has had an amazing reception by the invited researchers, and consequently will be divided into two parts. Here, we introduce the first part that features 5 review-type and 25 research-type articles. For the 5 review-type contributions, (i) Wojciechowski et al. (article no. 1900144) discuss the industrial opportunities of PSCs; (ii) Yin et al. (article no. 1900135) and Pang et al. (article no. 1900215) review the progresses of PSCs based on formamidinium-based HPs and inorganic $CsPbIBr_2$ HPs, respectively; (iii) Liu et al. (article no. 1900213) summarize the strategies for making high-performance tin-based PSCs; (iv) Fan et al. (article no. 1900148) provide prospects on environmentally friendly and stable lead-free perovskites. Regarding the research-type contributions, the following key topics are covered.

Tailoring perovskite properties and stability: Yan et al. (article no. 1900078) report the use of block copolymers for grain boundary passivation in $MA_{0.7}FA_{0.3}PbI_3$ HPs. Ma et al. (article no. 1900212) use bifunctional dye molecules for enhancing the properties and stability of inorganic $CsPbIBr_2$ HPs. Zhao et al. (article no. 1900197) show that black phosphorus can promote photostability in $MAPbI_3$ HPs. Chen et al. (article no. 1900090) and Liu et al. (article no. 1900220) demonstrate new perovskite composition engineering strategies. Etgar et al. (article no. 1900128) show how to tailor the optical properties in already crystallized HPs. Flávia Nogueira et al. (article no. 1900199) reveal the mechanisms underlying the property enhancement of 3D HPs via layered HPs incorporation.

Improving charge-transporting layers and electrodes: Various new types of electron-transporting layers for high-performance PSCs are demonstrated (water-based TiO_2 nanocrystals Zhao et al. [article no. 1900167], UV-treated SnO_2 by Mora-Seró et al. [article no. 1900191], γ-Ga_2O_3 nanocrystals by Wang et al. [article no. 1900201], Co-doped TiO_2 by Liu et al. [article no. 1900176], PCBM/conjugated polymer composite by Yang et al. [article no. 1900207], and molecular-engineered PCBM by Troshin et al. [article no. 1900223]). New hole-transporting materials (HTMs) are also designed by Xu et al. (article no. 1900119), Yip et al. (article no. 1900265), Xu et al. (article no. 1900196), Getautis et al. (article no. 1900224), and Nazeeruddin et al. (article no. 1900172), which may mitigate the existing issues associated with the commonly used Spiro-OMeTAD HTMs. Furthermore, Huang et al. (article no. 1900209) and Lin et al. (article no. 1900146) show the promise of sputtered Au and carbon quantum-dots as conducting contacts for PSCs, respectively.

Modifying device interfaces: Unger et al. (article no. 1900088) and Song et al. (article no. 1900118) demonstrate alkali salts and Zwitterionic polymers for interface modification in PSCs, respectively. An interesting in-situ interface-modification approach is demonstrated by Hu et al. (article no. 1900089) for enhancing PSC stability.

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Developing lead-free perovskites: Yao et al. (article no. 1900218) present a new vapor-assisted solution method for making sulfur-incorporated bismuth-based lead-free PSCs. Jen et al. (article no. 1900285) employ a trihydrazine dihydriodide additive for boosting formamidinium tin iodide PSCs to 8.48% PCE.

In closing, this collection of papers demonstrates the most recent progress in understanding and developing PSCs from various scientific and technological aspects. We envision they will bring broad attention from the field of photovoltaics and stimulate more significant effort towards more efficient, stable, eco-friendly PSCs in the future. We are also looking forward to releasing the second part of this special issue of Perovskite Photovoltaics and Optoelectronics soon, and to sharing more research progress and opinions on perovskite sciences and technologies.