Solar RRL
www.solar-rrl.com

Towards the Next Decade for Perovskite Solar Cells

Iván Mora-Seró, Michael Saliba,* and Yuanyuan Zhou**

In 2009, a study on the use of halide perovskites as light sensitizers in liquid dye-sensitized solar cells went almost unnoticed until three years later, when an outstanding performance for all-solid perovskite solar cell was reported. Although these materials were already well known in the literature, it was their use for photovoltaic applications that boosted the interest in this family of materials.

This finding was particularly timely as the mature research fields of dye-sensitized and organic solar cells rapidly developed the potential of halide perovskite photovoltaics and with great enthusiasm. The past decade has witnessed the rapid emergence of perovskite photovoltaics as a consolidated research field. The next decade of halide perovskite has to now show the feasibility of halide perovskites for industry. Many researchers from academia or from companies are working feverishly to make halide perovskites a reality in commercial solar cells, for example with carbon printable electrodes or in tandem devices with silicon solar cells. The previous decade has also highlighted the huge potential of halide perovskite for optoelectronic applications beyond photovoltaics as LEDs, lasers, photodetectors, or scintillators, just to cite some examples. Outstanding optical properties have shown application as white LEDs and TV screens, opening new possibilities for commercialization. It is likely that halide perovskite will still surprise us with their amazing properties in the coming decade, where a massive push towards industrialization is expected in tandem with the scientific research community.

The developments of a decade of research in halide perovskite solar cells and the future of this technology was broadly discussed in the complementary symposia *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), and another more recent set of symposia, i.e. *ET08: Halide Perovskites for Photovoltaic Applications—Devices, Stability and Upscaling* and *EN09: Advances in the Fundamental Science of Halide Perovskite Optoelectronics* at the 2019 MRS Fall Meeting (Dec. 1–6, 2019, Boston, MA, USA) Combining these symposia with the 10th anniversary of perovskite photovoltaic, *Solar RRL* launched a special issue on *Perovskite Photovoltaics and Optoelectronics*, collecting not just outstanding contributions within these symposia but also extending the invitation to a broad range of leading groups around the world. The reception of this special issue has been exceptional, leading to two parts due to the high number of contributions. The first part was published in 2019 as issue 9 in volume 3 of *Solar RRL*.

We are pleased to present here the second part that provides visions of current trends and perspectives in halide perovskite research.

The second part presents 11 reviews and 18 research-type articles on different topics:

The review manuscripts analyze different aspects of perovskite solar cells. Hu et al. summarize the progress in multifunctional molecules (article number 1900248). Chen et al. review interface engineering (article number 1900257), while Zhou et al. provide an overview of carbon electrode solar cells (article number 1900190). Yang et al. discuss the crystallization process (article number 1900200). Park et al. (article number 1900251) study surface engineering, whereas Tan et al. focus on the NIR response (article number 1900280). Zhang et al. analyze Pb-site doping (article number 1900227). Two different approaches for Pb-free are reviewed by Hong et al. who analyze Sn-based solar cells (article number 1900310) and by Chen et al. who overview Pb-Free Double Perovskites (article number 1900306). Light management in tandem solar cells is outlined by Zhang et al. (article number 1900206). Beyond solar cells, a progress report on recent advances in lead halide perovskites for radiation detectors is presented by Yan et al. (article number 1900210).

Perovskite thin film fabrication processes. Yang et al. report the sequential roll-to-roll microgravure printing and slot-die coating deposition (article number 1900204). Sequential processing of mixed formamidinium and methylammonium halide perovskite solar cells is analyzed by Ding et al. (article number 1900183). Zhong et al. extend the antisolvent spin coating method to $10 \times 10\,cm^2$ perovskite solar module approaching 18% (article number 1900263).

Tailoring perovskite properties in perovskite solar cells. Dar et al. report the effect of guanidinium salts (article number 1900234), while Gao et al. present the synergy of plasmonic Ag nanorod to enhance efficiency in planar devices (article number 1900231). Nickel et al. study light-induced defect generation in $CH_3NH_3PbI_3$ thin films and single crystals (article number 1900216).

I. Mora-Seró
Institute of Advanced Materials (INAM)
Universitat Jaume I
Av. Sos Baynat, s/n, 12071 Castello, Spain
E-mail: sero@uji.es

M. Saliba
Institute of Materials Science
Technical University of Darmstadt
Alarich-Weiss-Strasse 2, D-64287 Darmstadt, Germany
E-mail: michael.saliba@opto.tu-darmstadt.de

M. Saliba
Helmholtz Young Investigator Group
IEK5-Photovoltaik
Forschungszentrum Jülich
52425 Jülich, Germany

Y. Zhou
School of Engineering
Brown University
Providence, Rhode Island 02912, USA
E-mail: yuanyuan_zhou@brown.edu

DOI: 10.1002/solr.201900563

Improving charge-transporting layers and electrodes. He et al. report the use of a novel hole transporter (article number 1900189), while Li et al. study the doping in the active layer and in an electron transport hydrophilic fullerene derivative (article number 1900249). Different aspects of SnO_2 selective contacts are analyzed. Zhou et al. report the energy modulation in diboron modified SnO_2 (article number 1900217). Wang et al. study the interconnected SnO_2 nanocrystals electron transport layer (article number 1900229), while Song et al. report low-temperature e-beam deposition of Zn-SnO_x for stable and flexible perovskite solar cells (article number 1900266).

Carbon stack perovskite solar cells. Yang et al. present a study of the interfacial post-treatment (article number 1900278), whereas Meredith study the electro-optics of carbon stack perovskite solar cells (article number 1900221).

Modifying surface interface. Shen et al. report the growth of amorphous passivation layer using phenethylammonium iodide to enhance cell performance (article number 1900243). Dai et al. study the regulation of interfacial charge transfer and recombination (article number 1900198).

Concentrated sun light for stability characterization. Katz et al. and Visoly-Fisher analyzed the photodegradation of $MAPbI_3$ and bias-dependent stability of perovskite solar cells using natural and concentrated sunlight in (article number 1900270) and (article number 1900335), respectively.

Less Pb perovskite solar cells. Boix et al. report the synthesis of a narrow bandgap perovskite, $FAPb_{0.5}Sn_{0.5}I_3$, through evaporation methods for solar cell applications (article number 1900283).

This second part of the special issue of *Perovskite Photovoltaics and Optoelectronics* highlight that the optimization of fabrication and interfacial characteristics remains a main research topic, while stability and Pb-free and less-Pb continues to be a trend in the field.

This second part gives a general overview on the current research in halide perovskite solar cells, that is now entering its second decade of intense research. We expect it will result in even more enhanced results with a particular focus on commercialization.