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Preface for Special Topic: Perovskite solar cells—A research update

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Over the last few years, tremendous progress has been made in the research field of perovskite solar cells. Not only are record power conversion efficiencies now exceeding 20%, but our understanding about the different mechanisms leading to this extraordinary performance has improved phenomenally. The aim of this special issue is to review the current state-of-the-art understanding of perovskite solar cells. Most of the presented articles are research updates giving a succinct overview over different aspects concerning perovskite solar cells.
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The research updates presented cover the following topics:

- Behind the high efficiency of hybrid perovskite solar cells.[1]
- Thin films and solar cells by vapor phase reaction.[2]
- The electronic structure of hybrid perovskite layers and their energetic alignment in devices.[3]
- Luminescence in lead halide perovskites.[4]
- Characterization of perovskite solar cells: Towards a reliable measurement protocol.[5]
- Overview of progress about efficiency and stability on perovskite solar cells.[6]
- Strategies for improving the stability of perovskite solar cells.[7]
- Large-area processing in the upscaling of perovskite solar cells.[8]
- Challenges for highly efficient LEDs and the path towards electrically pumped lasing.[9]

The fabrication of perovskite thin films and solar cells (from solution and by vapor phase reaction) is covered in two summaries. Here a variety of different perovskite solar cell architectures are reviewed emphasizing the roles of different designs and processing parameters. Important for efficient devices is the electronic structure and the energetic alignment of the interfaces, which is covered in a further research update. Photoluminescence measurements can provide information about charge-carrier recombination dynamics and therefore significant insight into the operation mechanisms, which allows a targeted optimization of perovskite-based optoelectronic devices. On the subject of perovskite solar cell characterisation, a very important issue is the correct measurement of power conversion efficiency, which is not straightforward as many perovskite solar cells show strongly hysteretic behaviour. Here, the research community needs to agree on a standard measurement protocol that yields realistic power conversion efficiency and allows the comparison of different solar cell architectures fabricated and measured across different laboratories. Given that perovskite solar cells with impressive power conversion efficiencies have now been established, major efforts are commencing to improve stability towards realistic commercialisation targets, a review of which is covered in two articles. Another aspect that will need to be tackled before commercialisation becomes viable is large-area processing. The final review highlights that these amazing materials are not only suitable for solar cells, but may also be successfully employed in other applications such as LEDs or lasers. The combination of these select topics provides an excellent overview of the current state-of-the-art in hybrid perovskite research. At the same time,

these articles also strive to highlight the varied and challenging open questions and aspects that will need further attention over the coming years.

We are very pleased to present, following only two years after *APL Materials'* successful first special issue on perovskite solar cells, this second special issue dedicated to this rapidly developing field. As *APL Materials* is an open access journal, readers worldwide will be able to access all articles free of charge. Therefore, we are delighted that this special issue will serve a large audience of newcomers to the field who will benefit from this excellent and concise introduction as they embark on their own contributions to hybrid perovskite research. In addition, we are convinced that the breadth of areas explored and the numerous future challenges highlighted will also be of great interest to those already well established in the area of hybrid perovskite material research.

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