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Hybrid perovskites for photovoltaics and optoelectronics

Guest Editors

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Hybrid perovskites were traditionally studied for optoelectronic devices with significant success due to possibility of tuning different emission wavelengths with them. The interest in them exploded when they were used as the absorber material in a solar cell by Kojima *et al* [1] and their promising properties in the domain were made explicit. Since then, hybrid perovskites have unblocked the efficiency of organic solar cells that for years was slowly increasing close to 12%. Hybrid perovskites based solar cells are now reaching the efficiency levels of silicon solar cells and, due to the advantageous physical properties of the hybrid perovskites themselves, they represent a new class of solar cells. In this special issue, we present a series of original research articles dealing with some of the current research lines on hybrid perovskite devices, which cover the influence of the electron and hole transport layers, the importance of surface and interfaces, the stability improvement strategies to achieve long-term operation and the seek for lead-free materials.

The special issue starts with some articles of how the electron and hole transport layers affect the efficiency and the cost of hybrid perovskite devices. Chiang *et al* [2] study the use of IZO as a transparent conductive oxide for top illumination of perovskite solar cells to avoid the expensive (bottom) substrate that accounts by over 58% of the cost. Another article deals with alternatives TiO₂, an electron transport material with low mobility because of bulk defects and that requires an expensive high-temperature processing. Zhou *et al* have thus considered SnO₂ as a different option [3]. Then, Ono *et al* study the impact of pinhole defects at the hole transport layer on the device efficiency and stability, and study how to avoid the pinhole apparition during the spin coating process of Spiro-MeOTAD and polystyrene [4].

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Other aspects to be considered when optimizing the efficiency of the devices are the hybrid perovskite surfaces as well as the interfaces between the different layers in the device, since the transport properties are closely related to them. In this context, Liang *et al* study perovskite/fullerene heterojunctions and relate the anomalous hysteresis in the J-V curves due to the charge accumulation at the interface [5]. Jacques *et al* identify traces of an unknown structural feature in the fine-structure of x-ray diffraction Bragg spots, at an expanded region of the sample, probably near the sample surface [6]. Also, Zhumekenov *et al* study how to grow crystals of the electronic properties of CH₃NH₃PbI₃ exposing unconventional facets (i.e. the (0 0 2)) instead of the usual (2 0 0) or (1 1 2) facets. They observe striking differences in the device performances depending on the facet [7].

Efficiency is not everything in a device. Long-term stability is necessary for commercialization, so it is necessary to control the stability of hybrid perovskites towards temperature, air, humidity or even UV exposure. This special issue presents different approaches to reach higher stability of these materials. One is the combination of 2D and 3D perovskites, as shown by Zhang *et al* when using BDAPbI₄ and MAPbI₃ [8]. Another possibility is to encapsulate the hybrid perovskites based solar cells to protect them from the air and the humidity, as it is reported by Emami *et al* using a scalable compatible process by laser-assisted encapsulation [9]. Another strategy consists in finding more robust perovskites. This approach is experimentally illustrated by Aygüler *et al* with inorganic metal halide perovskites CsPbX₃ or KCF₃SO₃ [10]. Theoretically, inorganic perovskites have been studied by Huo *et al* [11] who have extensively explored by first-principles calculations the functionality as solar cell absorbers of almost 170 lead-free compounds, finally proposing some promising candidates as BaZrS₃, BaHfSe₃, SrZrSe₃, SrHfSe₃ and BaZrSe₃.

All these works illustrate some of the main research trends in this rapidly evolving discipline. We hope that hybrid perovskites will be soon widespread in everybody's life, making a step forward in the renewable energy and optoelectronics fields.

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