Perovskite Photovoltaics for Outdoor and Indoor Applications

Zhanglin Guo[1, 2]

[1] International Institute for Carbon-Neutral Energy Research (WPI-I2CNER), Kyushu University, 744 Motooka, Nishi, 819-0395 Fukuoka, Japan

[2] Center for Energy Systems Design (CESD), International Institute for Carbon-Neutral Energy Research (WPI-I2CNER), Kyushu University, 744 Motooka, Nishi, 819-0395 Fukuoka, Japan

E-mail: guo.zhanglin.903@m.kyushu-u.ac.jp

Halide perovskite solar cells (PSCs) have been attracting incredible attention in recent years due to their high potential as an alternative to the currently dominant silicon solar cells. PSCs offer advantages over silicon solar cells, including low cost, lightweight, easy fabrication process, and flexibility. These attributes enable diverse applications that Si PV cannot achieve, such as building-integrated photovoltaics (BIPVs), automotive integration, and indoor IoT applications. Thanks to the efforts of a large global research community of >40,000 researchers and insights gained from other PV technologies, the power conversion efficiency (PCE) of PSCs has increased dramatically from 3.8% in the first report in 2009 to over 26% today.[1] Further improvements in PCE can be achieved by combining two PV technologies with different bandgaps (E_g) to utilize sunlight more efficiently, such as perovskite/Si tandem solar cells, enabling better cost-effectiveness for commercialization. Another critical factor for the practical application of PSCs is ensuring their long-term durability, as they are sensitive to environmental stimuli like moisture, UV light, and high temperatures.

In this talk, besides providing a general background of PSCs (including the history and progress), I will talk about my work on developing wide-E_g perovskite PVs, which are essential for creating tandem solar cells. Compared to narrow-E_g perovskite PVs, the wide-E_g ones face the challenge of significant open circuit voltage (Voc) loss,[2] which is the main reason for their unsatisfactory PCE. To address this issue, I have developed techniques that significantly reduce Voc loss, achieving world-record Voc and PCE performance.[3-5] By reaching 92% of the theoretical Voc limit, the problem of large Voc loss for wide-E_g perovskite PVs has been solved, thereby advancing the development of tandem PVs. On the other hand, wide-E_g perovskite PVs are suitable for indoor applications (potential power source for IoT) due to their bandgap matching with the indoor light spectra (visible light only). I have studied the indoor performance and stability of these wide-E_g perovskite PVs, achieving ultra-high Voc, which has never been obtained by any other indoor PV technologies.[6] It is believed that much milder indoor conditions can avoid the harsh stimuli existing outdoors, thereby being a solution to enhancing the long-term durability of perovskite PVs. In conclusion, the advancements in wide-E_g perovskite PVs improve their suitability for tandem solar cells and open up new possibilities for efficient indoor photovoltaics, contributing to the broader adoption and commercialization of PSC technology.

Reference

1. A. Kojima, K. Teshima, Y. Shirai and T. Miyasaka, *J. Am. Chem. Soc.*, 2009, **131**, 6050-6051.
2. Z. Guo, A. K. Jena, G. M. Kim and T. Miyasaka, *Energy Environ. Sci.*, 2022, **15**, 3171-3222.
3. Z. Guo, A. K. Jena, I. Takei, G. M. Kim, M. A. Kamarudin, Y. Sanehira, A. Ishii, Y. Numata, S. Hayase and T. Miyasaka, *J. Am. Chem. Soc.*, 2020, **142**, 9725-9734.
4. Z. Guo, A. K. Jena, I. Takei, M. Ikegami, A. Ishii, Y. Numata, N. Shibayama and T. Miyasaka, *Adv. Funct. Mater.*, 2021, **31**, 2103614.
5. Z. Guo, S. Zhao, N. Shibayama, A. Kumar Jena, I. Takei and T. Miyasaka, *Adv. Funct. Mater.*, 2022, **32**, 2207554.
6. Z. Guo, A. K. Jena and T. Miyasaka, *ACS Energy Lett.*, 2022, **8**, 90-95.