178h Institute Interest Seminar Series (Webinar), I^{2}CNER
July 8, 2020

Understanding degradation mechanisms of hybrid perovskite solar cells

Advanced Energy Conversion Systems Thrust

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Metal halide hybrid perovskites are very promising for the light absorber of solar cells. By taking advantage of their bandgap tunability, high carrier mobilities, long carrier diffusion lengths, and compatibility with low-cost solution processing, the highest certified power conversion efficiency of 25.5 has been demonstrated from hybrid perovskite solar cells. However, the operational durability of hybrid perovskite solar cells is still problematic and, therefore, needs to be improved by clarifying their degradation mechanisms.

In I^{2}CNER, we found that there are many factors that strongly limit perovskite solar cell performance. The limiting factors include voids, carrier traps, defect states, grain boundaries, inefficient carrier diffusion, and ion migration in hybrid perovskite films. For example, we optimized the perovskite compositions and device architectures and introduced benzoquinone, a special interlayer and a self-assembled monolayer to remove these limiting factors. With these methods, we succeeded in improving the efficiencies and operational durability of hybrid perovskite solar cells. Table 1 displays the performance progress we obtained in I^{2}CNER. In 2019, we achieved a very high power conversion efficiency of up to 21.8% and a half-lifetime of up to 73,000 h. This half-lifetime is the highest values ever reported in any hybrid perovskite solar cell.

Table1. Progress of power conversion efficiencies and operational durability of hybrid perovskite solar cells we obtained in I^{2}CNER.

	2014	**2015**	**2016**	**2017**	**2018**	**2019**
Power conversion efficiency	0%	11%	15%	19%	21.5%	21.8%
Extrapolated half-lifetime	0 h	4,000 h	10,000 h	14,000 h	23,000 h	73,000 h

These values were measured under continuous solar illumination with AM1.5G and 100 mW/cm^2. The half-lifetime means time, at which efficiency decreases to half of the initial.