Fabrication of Hermetically Laser-Sealed Printable Perovskite Solar Devices Towards Superior Extrinsic Stability

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Abstract

A hermetic encapsulation is required to protect perovskite solar cells (PSCs) from the most relevant sources of degradation – humidity and oxygen. According to the IEC61646 PV standard test, commercial photovoltaic devices must be stable from - 40 ℃ to 85 ℃ and relative humidity of 85%. Therefore, to achieve the previously mentioned requirements, the PSCs should be fabricated with thermally stable layers and protected by a long-term stable hermetic encapsulation. Previously, we reported a laser-assisted glass frit encapsulation that successfully achieved long-term stability for PSCs with n-i-p and HTM-free structures. An advanced dual laser beam glass frit sealing process was previously developed and optimized to hermetically encapsulate n-i-p PSCs at 65 ± 5 ℃ for a short processing time of < 60 s. In contrast, printable HTM-Free perovskite solar cells have been reported to be sealed with a single laser beam at 100 ℃ for a long processing time of *ca.* 35 min. Therefore, this work aims to use the dual laser sealing process to hermetically encapsulate HTM-Free PSCs and mini-modules. Moreover, a 100 x 100 cm^2 panel (*ca.* 234 cm^2) was manufactured using dual laser-sealed mini-modules (*ca.* 6 cm^2). The novel sealing process had no impact on the performance of the encapsulated devices, since the power conversion efficiency (PCE) of both small-area PSCs and mini-modules slightly increased from (8.27 ± 0.83)% to (10.75 ± 1.41)% and from (6.08 ± 0.32)% to (6.61 ± 0.49)%, respectively. After sealing 39 mini-modules in series and in parallel, the assembled panel delivered an average PCE of 4.71% when exposed to 789 W m^{-2} solar irradiation. In conclusion, this study indicates that dual laser sealing has a low impact on the performance of lab-scale devices and mini-modules, and it also reinforces that this sealing procedure can be suitable for encapsulating large-area PSCs.

Keywords

Perovskite Solar Cells, Hermetically Laser-Assisted Glass Frit Encapsulation, Stability, Scalability

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