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Dual Laser-assisted Glass Frit Encapsulation for Efficient and Long-Term Stable N-I-P Perovskite Solar Cell

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Abstract

According to international standards (IEC 61646 climatic chamber tests), photovoltaic devices must be long-term stable under a temperature range of -40 ℃ to 85 ℃ and to a relative humidity of 85%. For this reason, perovskite solar cells (PSCs) must be manufactured from stable materials and encapsulated appropriately to avoid degradation due to moisture and oxygen exposure. Laser-assisted glass frit encapsulation has been successfully used to achieve long-term stable PSCs with n-i-p and HTM-free structures. The laser-sealing process can be achieved with a single laser beam or dual laser beams. The laser-assisted glass frit encapsulation method was initially reported for hermetically encapsulated HTM-free PSCs at *ca.* 100 ℃ using a single laser beam. Later, an advanced novel dual laser beam glass frit sealing process was developed and optimized to hermetically encapsulate n-i-p PSCs, allowing to decrease the process temperature to 65 ± 5 ℃. The present work reports the use of advanced laser-assisted glass frit encapsulation using dual laser beams for encapsulating PSCs devices with different electron transport layers (ETL) and hole transport layers (HTL). Preliminary results of encapsulated n-i-p PSCs with poly[bis(4-phenyl)(2,4,6-trimethylphenyl) amine] (PTAA) as HTL at a process temperature of 65 ± 5 ℃ for 1 h, presented a reduction in average power conversion efficiency (PCE) from 14.18 ± 2.4% to 12.32 ± 0.90%. The reduction in performance was mainly due to a decrease in fill factor (FF) from 0.67 ± 0.09 to 0.56 ± 0.04. It was registered a slight decrease in open circuit voltage (V_{OC}) from 1.01 ± 0.03 V to 0.99 ± 0.02 V, while the short circuit current density (J_{SC}) increased from 20.73 ± 0.77 mA cm^{-2} to 21.97 ± 0.46 mA cm^{-2}. The performance loss of *ca.* 10% is related to the long exposure to heat during the laser sealing process.

Keywords

Hermetic Encapsulation, Dual Laser, Glass Frit, Perovskite Solar Cell

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