Low-temperature strain-free semi-solid/liquid encapsulation for perovskite solar cells and modules

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Perovskite solar cells (PSCs) are emerging as a high-efficiency photovoltaic technology, but their instability is posing challenges to their commercialization. Recent stability assessments have been carried out on perovskite solar farms [1], but reliable accelerated aging tests on large-area cells remain insufficient. To achieve a Levelized Cost of Energy (LCoE) comparable to that of commercial silicon photovoltaics, perovskite solar modules (PSMs) are expected to provide stable output for at least 20 years in outdoor conditions, while withstanding, among the others, thermomechanical stresses caused by temperature fluctuations. In this study, we present an innovative industrially compatible encapsulation process characterized by the lamination of low-temperature strain-free semi-solid/liquid encapsulant adhesives onto PSCs/PSMs. In addition, the incorporation of two-dimensional (2D) hexagonal boron nitride (*h*-BN) flakes, produced by liquid-phase exfoliation [2], into the polymeric matrix enhances the barrier and thermal management properties of the encapsulant [3]. The proposed encapsulated PSCs and PSMs withstood multifaceted accelerated aging tests, including ISOS-D1 preconditioning (240 h), ISOS-D2 (85°C, >1000 h), ISOS-L1 (light soaking, >1000 h), as well as a customized thermal shock test (200 cycles) and modified humidity freeze test (10 cycles), retaining more than 80% of their initial power conversion efficiency. Our results represent a significant progress towards the realization of long-term stable PSMs by using industrially compatible advanced laminable composite encapsulants enabled by 2D materials.

References

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Figures

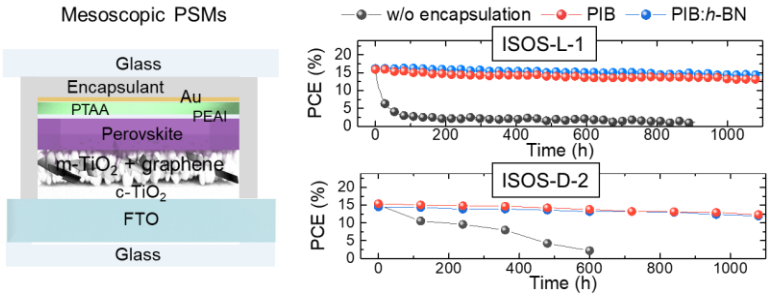

Figure 1: Schematic of the cell layout (active area = 1 cm²), in which the non-compact layers of the device are fully covered by the encapsulant.

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