Two-dimensional material-enabled encapsulation for perovskite solar cells and modules

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Perovskite solar cells (PSCs) have emerged as a high-efficiency photovoltaic technology, but their instability has posed challenges to their commercialization. Recent stability assessments have been conducted on perovskite solar farms[1], but reliable accelerated aging tests on large-area cells remain scarce. To achieve a Levelized Cost of Energy (LCoE) comparable to commercial silicon photovoltaics, perovskite solar modules (PSMs) are expected to provide stable output for at least 20 years in outdoor conditions, while withstanding thermomechanical stresses caused by temperature fluctuations. In this study, we present an innovative industrially compatible encapsulation process by laminating a strain-free two-dimensional (2D) material-based encapsulant adhesives onto PSC/PSMs. The incorporation of 2D hexagonal boron nitride (h-BN) flakes, produced by liquid-phase exfoliation of their bulk counterpart[2], into the polymeric matrix is beneficial for the barrier and thermal management characteristics of the encapsulant[3]. The as-produced encapsulated PSCs and PSMs withstood multifaceted accelerated aging tests, including ISOS-D1 (shelf life storage under ambient conditions), ISOS-D2 (85°C, >1000 h), ISOS-L1 (light soaking, >1000 h), as well as customized thermal shock (200 cycles with abrupt temperature changes between +85°C and -40°C) and customized humidity freeze tests (10 cycles with abrupt temperature changes between +85°C and -40°C and including a water immersion step before device freezing), retaining more than 80% of their initial efficiency. Our results represent a significant progress towards the realization of long-term stable PSMs by utilizing industrially compatible laminable advanced composite encapsulants enabled by 2D materials.

References

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Figures

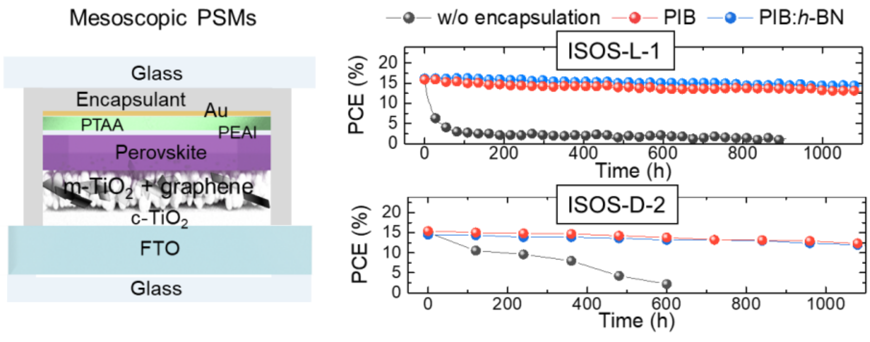

Figure 1: Schematic of the cell layout (active area = 1 cm^2), in which the non-compact layers of the device are fully covered by the encapsulant.

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