Outdoor evaluation of perovskite modules and panels enabled by 2D materials interface engineering

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Perovskite solar cells (PSCs) have gained substantial attention in the last decade as a promising energy source for high-power lighting in solar farms and low-power lighting in Internet of Things devices. The power conversion efficiency (PCE) of Perovskite Solar Cells (PSCs) has exceeded 26% and is nearing the efficiency of the best crystalline silicon solar cells. The remarkable PCE observed in laboratory and small-area cell testing should also be applicable to large-area photovoltaic (PV) panels in real outdoor conditions. To enhance the manufacturability of this method, interface engineering can be integrated with solution-processable 2D materials like graphene and transition metal dichalcogenides. Integrating two-dimensional (2D) materials enhances the charge dynamics at the interfaces and protects the perovskite layer from environmental agents such as oxygen, moisture, and metal ions. 5 square metres of perovskite PV panels were utilised in a solar farm on the HMU campus in Crete for outdoor field testing, and the actual energy generation output was examined. The solar farm was monitored continually using homemade developed maximum power point trackers. A correlation was identified between the farm's exterior performance and the environmental conditions documented by a weather station. The solar farm generated a peak output of over 260 W, demonstrating the scalability of the proposed system. Over the course of a year, the solar farm's energy production experienced a significant 20% decrease in photovoltaic efficiency after just eight months of being operational. Additionally, the electrical properties of the solar farm were observed in relation to temperature and light intensity following the T80 period. The study revealed that the solar farm experienced degradation from exposure to high temperatures, solar irradiance, moisture, and oxygen leading to lamination failure. Light-soaking was observed, showing distinct behavioural patterns before and during the solar farm's degeneration during the dark recovery process. During the monitoring period, the perovskite modules exhibited optical flaws that demonstrated the negative impact of lamination failure. The solar farm's power output dramatically reduced because moisture and oxygen infiltrated the PV modules due to lamination failure. The data analysis showed that perovskite panels are suitable for outdoor use in high-temperature environments, as in locations with high levels of sunlight.