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Continuous Atmospheric Pressure Plasma Enhanced CVD for the Large Area Deposition of TiO2-x Electron Transport Layers for PV Applications

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In recent years, perovskite solar cells have emerged as an attractive technology for next generation solar modules, combining high power conversion efficiencies with relatively low cost and abundant materials. However the component layers are typically produced by spin coating or vacuum processes, which precludes or adds significant cost to large area application. To this end, we describe the production of highly effective TiO_{2-x} electron transport layers (ETL) via a continuous atmospheric pressure, plasma enhanced CVD (AP PECVD) process. The films are evaluated in mesoporous perovskite cells and demonstrate cell performance matching or exceeding that achieved by an optimised sputtering process (13.57 vs 13.15 % Maximum Power Point for 1 cm^2 cells), suggesting significant potential for continuous large area production. Whilst operation at atmospheric pressure may be expected to result in compromised film properties compared to vacuum processes, these films, deposited on a 10 x 10 cm substrate, are shown to be sufficiently thin (lower 100 nm) to facilitate electron transport and minimise series resistance whist being sufficiently dense and pinhole free to provide a hole blocking function, essential to prevent recombination with electrons from the TCO electrode. The production of device quality films represents a significant step forward, with the demonstrator unit clearly showing the potential for scale up. It is envisaged this approach could be particularly advantageous if used on-line in combination with the APCVD process used to produce the transparent conducting oxide (TCO) electrode.

Keywords
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roll to roll