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Thesis abstract

Efficient perovskite single junction and perovskite silicon double junction solar cells

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Photovoltaic device has already played a significant role towards a net-zero future as it accounts for around three-quarters of renewable capacity additions worldwide in 2022. Next generation perovskite solar cells (PSCs) with their high efficiency credentials may further contribute to lowering the cost of power generation especially when implemented in a tandem cell configuration. To improve their commercial viability, the first part of the thesis studied perovskite crystallization process in ambient air. New insights were developed and was utilised to develop a thermal-radiation-assisted cyclization process to minimize the detrimental effect of moisture in perovskite crystallization in air. As a result, comparable power conversion efficiency were obtained compared to devices fabricated in inert atmosphere. For high efficiency perovskite-silicon tandem devices, a new self-assembly monolayer hole selective transport layer was designed, synthesised and applied in wide bandgap (1.67eV) perovskite and perovskite-silicon tandem. As a result, 28.9% PCE was achieved. Additionally, the encapsulated tandem cell passed the International Electrotechnical Commission (IEC) 61215 Thermal Cycling (200 cycles between –40 °C and 85 °C) test. The third part of the thesis reported an innovative use of morpholinium bromide (MLBr) as an interlayer between perovskite and C60 in wide bandgap perovskite and perovskite-Si solar cells. The choice of the more cost effective MLBr was innovative retaining the chemical structure and therefore benefit of piperidium bromide (PpBr) while the additional oxygen atom induces an electron rich environment for a larger dipole moment to enable better charge extraction to the C60. The impact of this work was demonstrated by the stability of the encapsulated MLBr and PpBr devices, which retained 97% of their initial efficiency after 400 thermal cycles, twice the number of cycles specified by the IEC 61215 photovoltaic module standard.

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