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Laminated high-performance semi-transparent perovsktie solar cells: Enabled by sticky polyethyleminine as glue

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ABSTRACT

Electric glue plays a key role in laminating top electrodes for organic and perovskite thin-film solar cells. However, there has been seldom reported for chemically reactive low–work function electrode yet. In this paper, polyethyleneimine (PEI) was developed as transparent top electrode adhesive, surface modifier for air-stable low–work function, and barrier to suppress the chemical corrosion of metal electrode in perovskite solar cells. The lamination was finished under room temperature with a pressure as low as 8 MPa, which is a very mild condition for device fabrication. The solar cells with transparent top electrode laminated for 10min had the best performances, in which the average value of PEI thickness between silver nanowires and the adjacent layer was found to play a key role in adjusting the performance of solar cells.

1. Introduction

Transparent top electrode is one of the critical components for semi-transparent solar cells. Solution-processed silver nanowire (AgNW) networks, which show excellent transparency, electrical conductivity, and mechanical flexibility, have been extensively investigated as low-cost top electrodes to replace the electrodes deposited by vacuum based thermal-evaporation or sputtering in the last few years [1]. However, owing to the ultra-low concentration of Ag NW dispersion system and the sensitivity of the perovskite thin film to solvent, the fabrication of solution-processed AgNW top electrodes upon devices is of great challenging [2,3]. As a result, the laminated AgNW electrodes were also reported as one of most important alternatives for avoiding the shortcomings of direct solution-processed methods.

Most of reported solar cells were laminated using electric glues with two-in-one advantages to adhere the electrodes, which mean the glues should also be work function modifiers. So they were usually chosen from traditional materials for device fabrication to ensure its electric properties. High-work function materials such as PEDOT:PSS with [4] or without [5] D-sorbitol, poly (triarylamine) (PTAA) [6], and spiro-OMeTAD [7] have been the most used electric glues, though insulating materials such as pressure sensitive adhesive was also seldom reported [8]. However, there has been no chemically reactive low–work function glue reported for laminated top electrode yet. Besides, the supporting substrate has been remained for their self-encapsulating nature [9,10], as well as been removed for single [5] or tandem [11] solar cells fabrication.

For complete electrical contact between laminated electrode and the underlying layer, heating more than 90 °C temperature [4,7,12] or pressing with more than 40 MPa [5,7] were usually applied during the operation. However, considering the potential danger of device degradation, room temperature and lower pressure should be as important as solvent free for the solar cells lamination in the future.

In this paper, we have discovered a new application innovatively for polyethyleneimine (PEI) with three-in-one advantage including transparent glue, as well as surface modifiers for air-stable low–work function [13] and barrier to suppress the chemical corrosion of metal electrode [3]. It was also used for protective coating in devices [14,15]. This kind

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