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Fabrication and characterization of a solution-processed electron transport layer for organic-inorganic hybrid halide perovskite photovoltaics

Yang-Yen Yu[1,2*], Chia-Fen Teng[1], Ching Tseng[1], Zhong-Qi Wang[1]

E-mail: yyyu@mail.mcut.edu.tw

[1]: Department of Materials Engineering, Ming Chi University of Technology, No.84, Gongzhuan Rd., Taishan Dist., New Taipei City 24301, Taiwan.

[2]: Department of Chemical and Materials Engineering, hang Gung University, No.259, Wenhua 1st Rd., Guishan Dist., Taoyuan City 33302, Taiwan

Abstract

In this study, suspended zinc oxide nanoparticles were used as the electron transport layer in trans-perovskite solar cells. The perovskite film was prepared by a liquid two-step method, and the crystallinity, surface morphology, and optical and photoelectric properties of the perovskite films were then investigated. The results showed that the crystallinity and film compactness of the perovskite could be controlled by the stoichiometric quantity and the perovskite formation rate. Moreover, the film morphology was affected by the annealing temperature, duration, and the amount of toluene solvent, which could be leveraged to enhance the efficiency of the device due to the charge trapping defect. The optimal annealing temperature and duration were 80 °C and 10 min, and the optimal volume ratio of isopropyl alcohol to toluene was 9:1. The highest performing perovskite solar cells in this study exhibited an energy conversion efficiency of 15.78 %, a short-circuit current of 20.80 mA/cm^2, an open circuit voltage of 1.10 V, and a fill factor of 0.69.

Keywords: Perovskite solar cell, Zinc oxide, Electron transport layer.

1. Introduction

To solve increasingly serious energy and environmental problems, attention has been turned to the development and utilization of energy sources. Amid the variety of energy technologies, photovoltaic power generation is undoubtedly one of the most promising directions. Although the industrialization of traditional silicon-based solar cells have been achieved and they have a mature market, their cost cannot compete with traditional energy sources and the pollution and energy consumption issues caused by the manufacturing processes affect their range of applications. Therefore, research and development of high efficiency, low cost solar cells is necessary [1-4]. Perovskite solar cells (PSCs) have attracted considerable attention because the power conversion efficiency (PCE) of PSCs has been increased substantially from 3.8% to 22.1% at the beginning of 2016; thus, thin-film solar cells such as dye-sensitized and organic solar cells have emerged [5-7].

Perovskite materials exhibit excellent photoelectric properties, such as high absorption in the visible spectrum and good electron and hole transport capacity [8-11]. By controlling the chemical composition, the bandgap can be tuned in the range of 1.1–2.3 eV [12-15]. Perovskite materials have therefore been widely used in double-layer metal oxides and planar heterogeneous interface solar cells as the light absorption layer