AIChE

Effect of ZnO-Based TCO on the Performance of a-Si H(n)/a-Si H(i)/c-Si H(p)/Al BSF(p+)/Al Heterojunction Solar Cells

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Inclusion of ZnO-based transparent conducting oxide (TCO) film layer into amorphous silicon/crystalline silicon (a-Si/c-Si) solar cell enhances its photovoltaic conversion efficiency. These findings have been confirmed here, using Afors HIT software. The simulation study is performed onto a solar cell that was originally lab prepared so as to use its measured parameters in the simulation. The ZnO-based TCO films were electrodeposited on n-type (100) silicon wafer and were simulated. X-ray diffraction (XRD) pattern confirms the zinc blende nature of the TCO layer, and show that the preferred orientation of ZnO films is (002). Scanning electron microscopic (SEM) imaging confirms nano-size nature of the ZnO based TCO film. For comparison purposes, cells with and without TCO layers are investigated by simulating photo-current versus applied potential (J–V) plots. Values of fill factor (FF), short circuit current density (J_{sc}) open circuit potential (V_{CO}) and conversion efficiency (η) are extracted. The energy band diagram, current density and charge carrier generation/recombination phenomena are in-depth analyzed to understand the mechanism of enhancement in the hetero-junction cell performance. Values of quantum efficiency (QE) are also simulated. The results show that the solar cell heterojunction is hypersensitive to the ZnO layer. The added value of using the ZnO-based transparent conductive oxide (TCO) layer, in enhancing intrinsic thin layer (HIT) solar cell conversion efficiency, is assessed by critically comparing it with a control cell having no ZnO layer. © 2018 American Institute of Chemical Engineers Environ Prog, 2018

Keywords: HIT solar cell, efficiency, ZnO-based TCO layer

HIGHLIGHTS

- ZnO based transparent conductive oxide (TCO) films were prepared by electro-deposition anodization on n-type (100) silicon wafer
- Simulation with AFSORS-HIT exhibited enhancement in ZnO/a-Si:H/n a-Si:H/i-c-Si/p/Al BSF/Al solar cell performance compared with control cell with no ZnO.
- The simulations of a-Si/c-Si heterojunction solar cell were carried out to reveal the cell parameters.
- Inclusion of ZnO-based TCO enhances PEC performance of the HIT solar cell.

INTRODUCTION

ZnO-based transparent conductive oxide (TCO) films exhibit high transmittance (visible region) and soundly high electrical conductivity. One example of such films is the widely used indium tin oxide (ITO). Front contact films are thus currently being extensively used as components in optoelectronic devices such as: heterostructures with intrinsic thin layer (HIT) solar cells, light emitting diodes (LEDs) flat, and touch panel displays [1,2]. Zinc oxide (ZnO) is emerging as an alternative to ITO in the above mentioned applications. Interest in ZnO is justified by its low cost, availability, and environmental friendliness. Heterojunctions with HIT cells, developed first by Sanyo Ltd, are silicon cells that exhibit high efficiency of crystalline silicon (a-Si:H): This structure involves both the emitter and the back surface field (BSF)layers. HIT solar cells have already shown high efficiencies of approximately 22% (in laboratory) and approximately 20% at commercial scale, where the Czochralsky (CZ) method is used to produce n-type crystalline silicon (c-Si) [3,4]. Several methods are used to prepare ZnO films, such as pulsed laser deposition (PLD) [5], spray pyrolysis [6], sol–gel process [7] chemical bath deposition (CBD) [8], chemical vapor deposition (CVD) [9], and others. However, these methods may not be suitable for large area coating, low temperature processing, or low cost production. The electro-deposition technique [10–12] is known to be one of the simplest and most effective ways to prepare ZnO films with sound characteristics at ambient temperatures. This technique is widely used in order to grow and functionalize oxide materials with specific chemical and physical properties. The advantages the electro-deposition technique for oxide films [13–15] are numerous, including ease of preparation, low cost, possibility of large-scale deposition, low temperature processing, and direct control of film thickness [5–9]. Literature [13] described the aqueous deposition using either zinc chloride or zinc nitrate.

Numerical simulation is useful to understand, design, and optimize solar cells with high performance. Modeling of crystalline silicon wafers is well understood. The amorphous layer

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