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Technical Report

Material selection for thin-film solar cells using multiple attribute decision making approach

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ABSTRACT

This paper presents a material selection approach for selecting absorbent layer material for thin-film solar cells (TFSCs) using multiple attribute decision making (MADM) approach. In this paper, different possible materials for absorbent layer and their properties like band gap, absorption coefficient, diffusion length, thermodynamic compatibility and recombination velocity is taken into consideration and MADM approach is applied to select the best material for thin-film solar cells. It is observed that Copper Indium Gallium Diselinide (CIGS) is the best material for the absorbent layer in thin-film solar cells out of all possible candidates. It was observed that the proposed result is in accordance with the experimental findings thus justifying the validity of the proposed study.

1. Introduction

The world today is facing a severe energy crisis as the conventional resources are getting depleted at a very fast rate forcing us to look at alternate energy sources. Solar energy is one promising alternative to meet the growing energy demands in future. thin-film solar cells (TFSC's) in particular are a promising approach to terrestrial and space photovoltaics. It has been more than 50 year since the photovoltaic devices were discovered. Since the discovery of a *p*–*n* junction Si photovoltaic (PV) device, the science and technology of PV devices (solar cells) and systems have undergone revolutionary developments. Today, the best single crystal Si solar cells have reached an efficiency of 25% [1] however the theoretical maximum value being 30%. In order to improve further the performance of TFSCs in terms of efficiency it is important to choose the material so as to give best performance.

Materials selection for engineering design needs a clear understanding of the functional requirement for each individual component and various important criteria/factors need to be considered. The selection of materials for thin-film solar cells in general and materials for its absorbent layer in particular is complicated as there are number of materials that has been proposed, however each of these materials have certain merits and limitations. [2,3].

The key performance indices for TFSC absorbent layer are band gap, absorption coefficient, diffusion length, thermodynamic compatibility and recombination velocity. This paper discusses a strategy for selecting suitable material for absorbent layer based on multiple attribute decision making (MADM) approach in order to improve the device performance.

This paper is organized as follows: Section 2 explains the thin-film solar cell design. Section 3 discusses the materials and their properties used in photovoltaic devices. Section 4 explains the selection criteria of materials. This section describes the decision making approach and details of technique for order preference by similarity to ideal solution (TOPSIS) while Section 5 includes the application of TOPSIS method to absorbent layer material selection in TFSCs. Section 6 presents the conclusions drawn from this study.

2. Thin-film solar cell design

A thin-film solar cell (TFSC), also called a thin-film photovoltaic cell (TFPV), is a junction device obtained by placing two electronically dissimilar materials together with a thin electronic barrier in between to separate charge. However, efficient devices must ensure high conversion efficiency of solar photons and high collection efficiency of excited charge carriers. A variety of junctions such as Schottky barrier, homojunction and heterojunction have been studied. Junctions can be abrupt, graded, buried etc., involving materials of different conductivity/type of conductivity [4]. The TFSC as shown in Fig. 1, consists of several layers of different materials in thin-film form. In general the solar cell consists of a substrate, transparent conducting oxide (TCO), window layer (*p* or *n* type), absorber layer, back contact and interfaces. Each of the component materials has different physical and chemical properties and each affects the overall performance of the device in some form or the other. A brief review of the current understanding of different TFSC components and interface chemistry is given below.

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