AIN SHAMS UNIVERSITY
FACULTY OF ENGINEERING
Electronics and Communications Engineering Department

Solar Cells Efficiency Enhancement Using Low Cost Methods

**A Thesis Submitted in partial fulfilment of the requirements of the degree of Doctor of Philosophy in Electrical Engineering
(Electronics and Communication Engineering)**

Submitted by:

Sameh Osama Ezzat Abdellatif

M.Sc. in Electrical Engineering

(Electronics and Communications Engineering)

Ain Shams University, 2012

Supervised By

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Dr. Rami Mohamed Ghannam
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Cairo, 201

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Examiners Committee

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Thesis: Solar Cells Efficiency Enhancement Using Low Cost Methods

Degree: Doctor of Philosophy in Electrical Engineering (Electronics and Communications Engineering)

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STATEMENT

This dissertation is submitted to Ain Shams University for the degree of Doctor of Philosophy in Electrical Engineering (Electronics and Communications Engineering).

The work included in this thesis was carried out by the author at the Electronics and Communications Engineering Department, Faculty of Engineering, Ain Shams University, Cairo, Egypt.

No part of this thesis was submitted for a degree or a qualification at any other university or institution.

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Abstract

Thin film solar cells (TFSCs) where first introduced as a low cost alternative to conventional thick ones. TFSCs show low conversion efficiencies due to the used low quality materials having weak absorption capabilities and thin absorption layers. In order to increase light absorption within the active layer, especially near its absorption edge, photon management techniques were proposed. These techniques could be implemented on the top of the active layer to enhance the absorption capabilities and/or to act as anti-reflecting coating structures. When used at the back side, their purpose is to prevent the unabsorbed photons from escaping through the back side of the cell. The attached structure will act to increase the optical path length of the photons, especially those in weak absorption portions of spectrum, increasing its probability of absorption.

In this thesis, we coupled the finite difference time-domain (FDTD) algorithm for simulating light interaction within the cell with the commercial simulator Comsol Multiphysics for describing carrier transports in thin film solar cells. An innovative algorithm for modelling the dispersion as well as absorption behaviour of the solar cells materials including the semiconductor active layer is demonstrated using Lorentzian-Drude (LD) coefficients. The algorithm is then tested by fitting its output with experimentally measured permeability of different materials used in TFSC fabrication, showing excellent agreement.

We thus compared the absorption profile in the different layers of the cell, the improvements in photon absorption in the active layer and the power conversion efficiency achieved by 3 different sandwiching light trapping structures: textured surface, nanowires and dielectric nanospheres on the top of the active layer. For textured surface as well as nanowires structures, an anti-reflective coating (ARC) effect is introduced on the surface reducing the reflected photons from the front surface of active layer. In the nanospheres topologies coupling modes will occur (whispering gallery modes) which Contributes to the absorption spectrum of the active layer material leading to efficiency enhancement. Besides that, 1D, 2D and cascaded photonic crystal structures are added at the back side of the active layer. These structures will contribute not only as a back reflector but also as a high diffracting order structures to increase the probability of total internal reflection inside the active layer. The simulation results are validated by previously measured experimental results when relevant.

Consequently, the experimental work is illustrated showing some primitive trials in fabricating a thin film of various materials and simple 1D photonic crystal structures for accrediting the simulation models. Finally, the main findings and outcomes of the thesis are drafted in the conclusion section. The pros and cons of different topologies implemented in this thesis and the corresponding enhancement in the total conversion efficiency of the TFSC were highlighted for each topology.

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