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SUBWAVELENGTH NANOSTRUCTURES FOR EFFICIENT THIN FILM SOLAR CELL

A Thesis Submitted in partial fulfillment of the requirements of a Master of Science degree in **Engineering Physics and Mathematics**

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Declaration

Herein, I declare that the work made and written in this thesis done by me only, and I have referred completely all aids used from other publications. This thesis is submitted to faculty of Engineering at Ain Shams University for the degree of Master of Science in Engineering Physics.
The work included in this thesis was originally carried out by the author at Engineering Physics 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

Subwavelength nanostructures enable the manipulation and molding of light flow in nanoscale dimensions. By controlling and designing nanoscale geometries we can control the coupling of light into specific active layer of solar cells materials and tune macroscale properties such as tranmission, reflection, and absorption.

Thin film solar cells (TFSCs) are a promising type of photovoltaics as its thickness in nanoscale. This advantage lead to a complete charge carrier collection depending on diffusion length of active material used in TFSCs. In addition, decrease the cost of material used. However, low thickness of TFSCs reduce the light absorption efficiency as absorption length of photon exceed the thickness. Therefore, the need to confine incident sun light into small active material thickness become a promising research point recently.

The thesis purpose is enhancing the light absorption efficiency without degradation in electron charge collection efficiency for Perovskite TFSCs using subwavelength nanostructures deposited on or inside or below active layer of solar cells.

Chapter 1 provides an overview about basic parameters of solar cells and how these parameters depend on material and generation of photovoltaics. Also, reported approaches for enhancing light trapping in many thin film solar cells types illustrated.

Chapter 2 describes physics behind recent nanophotonics methods used in solar cells, and defines critical parameters for coupling incident light within active layer of desired solar cells. Light scattering from metallic or dielectric nanoparticles, absorption and scattering efficiency for nanoparticle over substrate, metamaterial and antireflective surfaces studied in details.

Chapter 3 shows simulation tool used and its setup for recreating work on different solar cell materials. Starting with optical model for nanoscatter on substrate, followed by optical model for light absorption calculation, and end with electrical model for measuring overall power conversion efficiency.

In Chapter 4, we used Mie theory as a guide to calculate scattering and absorption cross section for plasmonics nanoscatters deposited on the top active

layer to select the optimum geometry and dimension for highest light absorption. Then, we investigated the performance of dielectric nanoscatters while comparing it with plasmonic materials. Moreover, we performed optical model to calculate light absorption percentage followed by electrical model to calculate photon-electron conversion efficiency.

In Chapter 5, we used Mie theory calculate scattering and absorption cross section for silver nanoscatters deposited inside active layer to select the optimum geometry and dimension for highest scattering efficiency and lowest absorption efficiency to enhance light absorption.

In Chapter 6, we proposed front dielectric and back plasmonic wire grating to achieve maximum theoretical absorption for incident sun light current. We performed optical model to calculate light absorption percentage followed by electrical model to calculate photon-electron conversion efficiency.

Keywords

Solar cells, Nanostructures, Thin film, Subwavelength, Mie theory, Dielectric, Plasmonic, Light scattering, Antireflective caoting.

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