



**AIN SHAMS UNIVERSITY
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ELECTRONICS & COMMUNICATION ENGINEERING**

Design and Simulation of Multi-Junction Solar Cells

A Thesis

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Statement

This thesis “Design and Simulation of Multi-Junction Solar Cells” is submitted to Faculty of Engineering, Ain Shams University for the degree of master in Electronics and Communication Engineering.

The work included in this thesis was carried out by the author. No part of this thesis has been submitted for a degree or a qualification at any other University or Institution.

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List of Symbols

I_o :	Ideal Reverse saturation current
I_{SC} :	Short circuit current
k :	Boltzmann constant
q :	Electron charge
T :	Temperature
n :	Ideality factor
V_{OC} :	Open circuit voltage
P_{max} :	Maximum power point
V_{max} :	Voltage at maximum power
I_{max} :	Current at maximum power
FF :	Fill Factor
η :	Conversion efficiency
P_{inc} :	Incident power
$h\nu$:	Photon energy
$conc$:	Doping concentration
$NC300$:	Density of conduction states at 300K
$NV300$:	Density of valence states at 300K
$EG300$:	Energy gap at 300K
ϵ :	Permittivity “dielectric constant”
χ_e :	Electron affinity

List of Abbreviations

<i>ARC:</i>	Antireflection Coating
<i>ASTM:</i>	American Society for Testing and Measurement
<i>BSF:</i>	Back Surface Field
<i>CONMOB:</i>	Concentration-Dependent Low Field Mobility
<i>CPE:</i>	Chemical Phase Epitaxy
<i>DJ:</i>	Dual Junction
<i>DOE:</i>	Design of Experiment.
<i>E_g:</i>	Energy bandgap
<i>EHP:</i>	Electron-Hole Pairs
<i>EQE:</i>	External Quantum Efficiency
<i>IMM:</i>	Inverted Metamorphic
<i>MBE:</i>	Molecular Beam Epitaxy
<i>MJSC:</i>	Multi-Junction Solar Cell
<i>MM:</i>	Metamorphic
<i>MOCVD:</i>	Metal Organic Chemical Vapor Deposition
<i>MUN (μ_n):</i>	Electrons Mobility
<i>MUP (μ_p):</i>	Holes Mobility
<i>NREL:</i>	National Renewable Energy Laboratory
<i>OPTR:</i>	Optical recombination
<i>PV:</i>	Photovoltaic
<i>SRH:</i>	Shockely-Read-Hall recombination
<i>TJ:</i>	Triple Junction
<i>TW:</i>	Tera-Watt

Abstract

The window and back surface field (BSF) layers are two important layers in the design of multi-junction solar cells. In this study, the focus is on selecting suitable materials for the top window layer as well as the top and bottom BSF layers of an InGaP/GaAs Dual-Junction (DJ) solar cell with introducing the effect of thickness variation of these layers. Furthermore, the doping concentration of the top and bottom BSF layers is optimized.

Another interest in this study is to present an optimization procedure for the design parameters of InGaP/GaAs/ InGaAs Triple-Junction (TJ) solar cell. The optimization technique is performed on InGaP/GaAs/Ge. The Ge sub-cell is then replaced by an InGaAs sub-cell and a comparison between the performance parameters of InGaP/GaAs/Ge and InGaP/GaAs/InGaAs TJ solar cells is investigated.

The simulations of DJ and TJ solar cells are carried out using advanced Silvaco TCAD tools. For each design, the solar cell performance parameters like open-circuit-voltage (V_{OC}), short-circuit-current density (J_{SC}), Fill Factor (FF) and the conversion efficiency (η) are extracted and compared with previously published results to ascertain the results of the present work.