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Exploring Possibilities to Enhance Silicon Solar Cell Efficiency by Downconversion of Sunlight

by

Muddassar Naeem

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Muddassar Naeem

Supervisors:

Prof. Jesper Munch

A/Prof. Murray Hamilton

A/Prof. Heike Ebendorff-Heidepriem

STATEMENT OF DECLARATION

To my family

Abstract

Improving the efficiency of solar cells is an active area of research in photovoltaic industry. The research work presented in this dissertation is based on a quest for better and improved silicon solar cells. The current work aims to explore different possibilities by studying advance approaches for PV applications. Additionally this work is intended to seek the feasibility of new photonic concepts for improving silicon solar cells.

In this work we have investigated solar downconverters consisting of tellurite glass. Their fabrication process is discussed followed by the experimental characterization. Optical measurements such as absorption spectra, fluorescence spectra and fluorescence quantum efficiency are undertaken. These optical measurements enabled to understand physical processes associated with the materials used.

Furthermore, the work presented in the thesis is focused on the realization of a downconverter. The work can be roughly sub-divided into two parts. One part identifies the suitable energy conversion materials and the second part deals with the development and demonstration of the experimental method for characterizing a downconverter. The final part of the work extends investigation for more efficient materials prior to their use at the practical level. We also propose an architectural design for the efficient use of a downconverter with a silicon solar cell.

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List of Abbreviations

Throughout the thesis, several abbreviations will be used to represent specific short descriptions or notations, the following is a list for the readers convenience. This list is not exhaustive but every effort has been made to maintain conformity of notations used here.

AM	Air Mass
ARC	Anti-reflection coating
BP	Band-pass
CdTe	Cadmium tellurite
CIGS	Copper indium gallium arsenide
DC	Downconversion
DS	Downshifting
ECL	Escape cone loss
EQE	External quantum efficiency
FQE	Fluorescence quantum efficiency
FTIR	Fourier transform infrared
IPV	Impurity photovoltaic
IQE	Internal quantum efficiency
LED	Light emitting diode
LP	Long-pass
NIR	Near-infrared
NPR	Non-radiative phonon relaxation
OFD	Organic flourescent dyes

PCE	Photon cascade emission
PV	Photovoltaics
QC	Quantum cutting
QD	Quantum dot
QS	Quantum splitting
RE	Rare-earth
SC	Solar cell
Si	Silicon
TIR	Total internal reflection
UC	Upconversion
UV	Ultraviolet
Vis	Visible
VUV	Vacuum ultraviolet