Declaration

I hereby declare that the work presented in this Thesis titled "*Cu_2ZnSnS_4 related Chalcogenide Absorbers: Thin Films and Heterostructure Photovoltaic Devices*" submitted to the Indian Institute of Technology Jodhpur in partial fulfilment of the requirements for the award of the degree of Doctor of Philosophy, is a bonafide record of the research work carried out under the supervision of Dr. Ambesh Dixit. The contents of this thesis in full or in parts, have not been submitted to, and will not be submitted by me to, any other Institute or University in India or abroad for the award of any degree or diploma.

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Certificate

This is to certify that the thesis titled "*Cu_2ZnSnS_4 related Chalcogenide Absorbers: Thin Films and Heterostructure Photovoltaic Devices*", submitted by *Goutam Kumar Gupta* (*PG201381002*) to the Indian Institute of Technology Jodhpur for the award of the degree of *Doctor of Philosophy*, is a bonafide record of the research work done by him under our supervision. To the best of our knowledge, the contents of this report, in full or in parts, have not been submitted to any other Institute or University for the award of any degree or diploma.

Ambesh Dixit
Ph.D. Thesis Supervisor

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List of Symbols

Symbol	*Description*
A	Area
α	Absorption coefficient
C	Capacitance
E	Energy
Ea	Activation energy
Eg	Bandgap
ε	Dielectric permittivity
FF	Fill factor
h	Plank constant
I	Current
$I0$	Reverse saturation current
Iph	Photo current
J	Current density
$J0$	Reverse saturation current density
Jsc	Short circuit current density
λ	Wavelength
μ	Mobility
n	Ideality factor
Nc	Effective density of states in conduction band
Nv	Effective density of states in valance band
q	Electronic charge
η	Efficiency
t	Time
τ	Minority carrier life time
θ	Diffraction angle
T	Temperature
Rs	Series resistance
Rsh	Shunt resistance
σ	Conductivity
V	Voltage
W	Depletion width
ω	Angular frequency
χ	Electron affinity
υ	Frequency
Ω	Ohm
z	Impedance

List of Abbreviations

Abbreviation	*Full form*
a:Si	Amorphous silicon
AFM	Atomic force microscopy
AM	Air mass
ASTM	American Society for Testing and Materials
AZO	Aluminum doped zinc oxide
c-Si	Crystalline silicon
CB	Conduction band
CBD	Chemical bath deposition
CBM	Conduction band minimum
CBO	Conduction band offset
CIGS	$CuIn_xGa_{1-x}(S, Se)_2$
CPV	Concentrated photovoltaic
CZTS	Cu_2ZnSnS_4
CZTSe	$Cu_2ZnSnSe_4$
CZT(S,Se)	$Cu_2ZnSn(S, Se)_4$
CZGS	Cu_2ZnGeS_4
CZGSe	$Cu_2ZnGeSe_4$
DC	Direct current
DSSC	Dye sensitized solar cell
EDX	Energy dispersive X-ray spectroscopy
EQE	External quantum efficiency
ICDD	International Center for Diffraction Data
ITO	Indium tin oxide
mc-Si	Multi crystalline silicon
min	Minute
NEXAFS	Near edge X-ray absorption fine structure
OPV	Organic photovoltaic
PCE	Photo conversion efficiency
PV	Photovoltaic
RF	Radio frequency
rpm	Rotation per minute
SEM	Scanning electron microscopy
SLG	Soda lime glass
TC	Texture coefficient
TCO	Transparent conducting oxide
TFSC	Thin film solar cell
TW	Terawatt
wt	Weight
XPS	X-ray photoelectron spectroscopy
XRD	X-ray diffraction
VB	Valance band
VBM	Valance Band minimum
VBO	Valance Band offset
vol	Volume