

List of Figures

<i>Figures</i>	<i>Title</i>	<i>page</i>
1.1	Schematic diagram showing development of solar photovoltaic cells in generations along with targeted cost and present cost for power generation along with thermodynamic limit of solar cells	2
1.2	Schematic diagram showing the working mechanism of (a) conventional P-N junction solar cell and (b) excitonic solar cell	3
1.3	Schematic diagram of quantum Dot Sensitized Solar Cells, lower panel shown side view of QDSSC and top panel shows working mechanism in brief	4
1.4	Schematic diagram showing carrier multiplication with impact ionization along with energy requirement of incident photon for multiexciton generation	5
2.1	Schematic representation of introduction of various photovoltaic cell technology since 1976	7
2.2	Schematic representation of four generation for solar photovoltaic with schematics of representative devices	8
2.3	Schematic diagrams showing structure and brief working mechanism for (a) dye sensitized solar cells and (b) quantum dot sensitized solar cells	10
2.4	Dependence of detailed balance efficiency of quantum dot solar cell over QDs absorber bandgap	11
3.1	Schematic diagram for problems identified for improvement in quantum dot sensitized solar cells after literature review	19
3.2	Schematic diagram for in-situ hydrothermal sensitization of mesoporous electrode along with their photovoltaic characterization	20
3.3	Schematic diagram showing transition metal doping in CdS sensitized quantum dot solar cells and their photovoltaic performance evaluation	21
3.4	Process flow for zinc titanate photoelectrode material preparation, photoelectrode preparation, sensitization and PV performance evaluation	22
3.5	Detailed balance efficiency calculation with ideal and limited open circuit potential conditions	23
4.1	Schematic diagram of synthesis of CdTe quantum dots using hydrothermal process and in-situ sensitization of mesoporous electrode using CdTe quantum dots	27
4.2	CdS quantum dots sensitization of mesoporous electrode using SILAR	28
4.3	ZnS passivation of sensitized mesoporous electrode using SILAR method	28
4.4	Schematic diagram showing generation of characteristic X-ray	30
4.5	Schematic diagram of components of X-ray diffractometer	31
4.6	Schematic diagram showing components of scanning electron microscopy	32
4.7	Schematic diagram of atomic force microscopy	32
4.8	Schematic diagram of UV-Vis spectrometer	33
4.9	Schematic diagram of FTIR spectrometer	34
4.10	Schematic diagram of fluorescence spectrometer	35
4.11	Schematic diagram of transmission electron microscope	36
4.12	Equivalent circuit models to fit impedance data (a) Transmission line model and (b) Simplified model	37
5.1	Schematic diagram explaining different sensitization schemes adopted in past	39
5.2	Schematic diagram showing process flow for experimental procedures for in-situ sensitization and PV testing	41
5.3	X-ray diffraction pattern for sensitized mesoporous electrode	42
5.4	Surface morphology of (a) sintered, (b) sensitized, (c) magnified sensitized mesoporous electrode and (d) cross section of mesoporous electrode	43
5.5	AFM topo-graphs for (a, b, c) sintered and (c, d, e) sensitized electrodes for different scanning area	43
5.6	AFM topo-graphs for (a) sensitized and (b) sintered mesoporous electrode for $1\ \mu\text{m} \times 1\ \mu\text{m}$ scan area	44
5.7	HR-TEM image for sensitized mesoporous electrode (a) Image showing organic covering and (b) d-spacing calculation for CdTe quantum dots	45
5.8	(a) absorption and emission spectra of dispersed QDs and (b) Absorbance calculated from	46

	diffuse reflectance measurement for sensitized, non-sensitized and ZnS treated electrode	
5.9	Photovoltaic response of sensitized electrode with and without ZnS treatment under 1 sun intensity illumination	46
5.10	Nyquist plots for (a, b) Without ZnS treatment sensitized electrodes and (c, d) with ZnS treatment under different bias conditions	48
5.11	Extracted parameter from impedance data fitted with equivalent circuit models (a) Counter electrode resistance R_{ce} , (b) transport resistance R_{tr} , (c) recombination resistance R_{rec} and (d) recombination capacitance C_{rec}	48
6.1	Schematic representation of adopted strategies for improvement in QDSSC	51
6.2	Schematic diagram showing possible energy level in transition metal doped CdS system	52
6.3	X-ray diffraction for Mn doped CdS sensitized mesoporous electrode (upper panel) and anatase diffraction reference (lower panel)	54
6.4	Surface morphology for (a, c) non- sensitized electrode and (b, d) sensitized electrode	55
6.5	Topography for (a, b, c) sintered and (d, e, f) sensitized electrode for different scanning area	55
6.6	Absorption of (a) Mn doped TiO_2/CdS electrode for different mole fraction and (b) different transition metal doped electrode	56
6.7	current voltage characteristic for (a) Mn doped TiO_2/CdS electrode and (b) different transition metal doped TiO_2/CdS QDSSCs	57
6.8	(a) Nyquist plot and fitted Impedance spectra for TM doped QDSSCs and (b) bode plots for TM doped QDSSCs	58
6.9	(a) Carrier lifetime for transition metal doped QDSSCs and (b) schematic diagram of introduced energy level diagram indicating Fermi energy of transition metal dopants	59
7.1	X-ray diffraction pattern for zinc titanate nano powder	63
7.2	(a) Estimated phase fraction of zinc titanate crystallographic phases and (b) schematic diagram for phase fraction variation with calcination temperature	63
7.3	(a, b) Tauc plot for zinc titanate powder with different calcination temperature and (c) vibrational spectra of zinc titanate nano powder with different calcination temperature indicated by labels	65
7.4	Surface morphology of (a, c) electrode A for sample calcinated at lower temperature and (b, d) shows surface morphology of electrode B calcinated at higher temperature	66
7.5	(a) absorption of electrode A and B and (b) absorption of sensitized electrode A and B	66
7.6	Photovoltaic response of best device made of Zinc titanate (a) electrode A and (b) electrode B	67
7.7	(a) Nyquist plot for electrode A, (b) Nyquist plot for electrode B, (c) bode plot for electrode A and (d) bode plot for electrode B	68
7.8	(a) Distribution of photovoltaic performance of zinc titanate electrode and (b) schematic diagram of QDSSCs	69
8.1	Schematic diagram showing operating principle of QDSSCs	71
8.2	(a) Generation rate and (b) ultimate efficiency for limited V_{oc} and ideal V_{oc} case	73
8.3	(a) Staircase carrier multiplication, (b) finite slope carrier multiplication, (c) ideal ultimate efficiency and non-ideal ultimate efficiencies for staircase carrier multiplication and (d) ideal and non-ideal ultimate efficiency for finite slope carrier multiplication	74
8.4	(a) open circuit voltage, (c) fill factor, (e) detailed balance efficiency with ideal E_{diff} , (b) open circuit voltage, (d) fill factor and (f) detailed balance efficiency with finite E_{diff}	76
8.5	(a) open circuit voltage, (c) fill factor, (e) detailed balance efficiency with finite E_{diff} and staircase carrier multiplication, (b) open circuit voltage, (d) fill factor and (f) detailed balance efficiency with finite E_{diff} and finite slope carrier multiplication	78