

List of Figures

Figures	Title	page
1.1	Two major techniques of solar energy conversion	3
2.1	(Left panel) Spectral distribution of solar radiation (i) extraterrestrial radiation, (ii) total radiation incident on the inclined (37°) earth's surface, and (iii) black body radiation at sun's surface temperature 5777K with O_3 , O_2 , H_2O , and CO_2 absorption bands. (Right panel) The air mass ratio (AM) and its numeric analog	7
2.2	Solar spectral irradiance for AM1.5 in wavelength range 0.3 to 2.5 μm . A blackbody radiation spectrum calculated using Plank's law for different temperatures	8
2.3	AM1.5 solar spectral irradiance in wavelength range 0.3 to 2.5 μm . The blackbody radiation for 450°C temperature. The red dashed curve represents the ideal spectral response for an absorber	8
3.1	(a) Schematic diagram of experimental setup for electrodeposition. (b) Electrochemical deposition experimental setup in our lab used to deposit spectrally selective absorber films	26
3.2	(a) Schematic of DC diode sputtering system. (b) Schematic of DC triode sputtering system	27
3.3	Schematic diagram of an RF sputtering system	28
3.4	Schematic diagram of (a) Planar Magnetron sputtering system and (b) Cylindrical Magnetron sputtering system	29
3.5	Schematic diagram of (a) unbalanced Magnetron sputtering system type I and (b) type II	29
3.6	An inside view of the vacuum chamber (process chamber) of combined RF/DC magnetron sputtering system in our lab used to deposit spectrally selective absorber films	30
3.7	An inside view of load lock chamber of combined RF/DC magnetron sputtering system	30
3.8	Front view of the combined RF/DC magnetron sputtering system	31
3.9	Tabular furnace (Nabertherm GmbH) in our lab used for annealing of spectrally selective absorber films in this study	32
3.10	Schematic of (a) X-ray tube structure and (b) characteristics X-ray generation	33
3.11	Schematic of (a) the geometrical arrangement of X-ray diffractometer and (b) the optical arrangement of thin film diffractometer	34
3.12	D8 advance powder X-ray diffractometer system in our lab used to characterize the structural properties in this study	34
3.13	(a) Schematic of optical diagram of Raman microscope. (b) Nomadic Raman microscope in our lab used to measure the vibrational properties of selective absorber materials in this study	35
3.14	(a) Schematic of the structure of a scanning electron microscope (SEM). (b) Carl Zeiss scanning electron microscope system conjunction with EDS in our lab used to characterize the surface properties and elemental analysis of selective absorber films.	36
3.15	(a) Schematic of an atomic force microscopy (AFM). (b) Scanning probe microscopy (SPM) instruments in our lab used to analyze surface parameters in this study	37
3.16	The DektakXT stylus profiler in our lab used to measure the film thickness of spectrally selective absorber materials coatings in this study	38
3.17	(a) A schematic view of the external DRA and (b) the optical design view of the external DRA used to measure the total reflectance of spectrally selective absorbers in this study	39
3.18	A schematic view of the optical design of internal DRA (Left), beam diagram of the accessory with the sphere cap in the D position (middle) and beam diagram of the accessory with the sphere cap in the S position (right)	40
3.19	Bruker FT-IR spectrometer vertex 70v in our lab used to collect the reflectance spectra of spectrally selective absorbers	40
3.20	(Left) Optical diagram of fixed angle (30 degrees) specular reflectance accessory. (Right) 30 degree horizontal fixed angle specular reflectance accessory	41
3.21	Schematic of the general instrumentation of thermal analysis	41
3.22	(a) Schematic of commonly used null-point type microbalance. (b) Perkin Elmer simultaneous thermal analyzer 6000 (STA 6000) in our lab used for thermal annealing of spectrally selective absorber films	42
3.23	(a) Potential-time excitation signal in a cyclic voltammetric experiment. (b) Typical cyclic voltammogram for a reversible redox process	43

3.24	(a) Schematic of the experimental setup for cyclic voltammetry experiments with three electrode configuration. (b) Iviumstat electrochemical workstation in our lab used to form the electrochemical measurements of spectrally selective absorber coatings	44
4.1	Schematic representation of black chrome and FeCo(C) NPs modified black chrome composite spectrally selective absorbers on Cu substrate	49
4.2	X-ray diffraction spectra of (a&b)(i) black chrome (BC) and (a&b)(ii, iii, iv) FeCo(C) NPs modified black chrome selective coatings with varying wt.% of FeCo(C) NPs deposited on (left panel) copper (Cu) and (right panel) nickel coated (Ni/Cu) substrates	51
4.3	(a) SEM micrographs of black chrome and (b, c&d) FeCo(C) NPs modified black chrome with varying wt.% of FeCo(C) NPs selective surfaces deposited on copper substrates	51
4.4	(a) SEM micrographs of black chrome and (b, c&d) FeCo(C) NPs modified black chrome with varying wt.% of FeCo(C) NPs selective surfaces deposited on copper substrate. (d) SEM cross-section of thickness measurements	52
4.5	(right panel) AFM surface morphology (a) of black chrome and (b, c&d) FeCo(C) NPs modified black chrome with varying wt.% of FeCo(C) NPs selective surfaces deposited on nickel coated copper substrate. (Left panel) Average roughness vs. wt.% of FeCo(C) NPs	52
4.6	EDS elemental analysis of (a) of black chrome and (b, c&d) FeCo(C) NPs modified black chrome with varying wt.% of FeCo(C) NPs selective surfaces deposited on the copper substrate	53
4.7	Reflectance spectra versus wavelength of black chrome and FeCo(C) NPs modified black chrome with varying wt.% of FeCo(C) NPs selective coatings deposited on (a) Cu and (b) nickel coated Cu substrates. Calculated absorptance values vs. varying wt.% of FeCo(C) NPs are represented an inset in the graphs a&b.	54
4.8	Reflectance spectra versus wavelength in the range of 2.5 – 25 μm of black chrome and FeCo(C) NPs modified black chrome with varying wt.% of FeCo(C) NPs selective coatings deposited on nickel coated Cu substrates. Calculated emittance values vs. varying wt.% of FeCo(C) NPs have represented an inset in the graphs.	55
4.9	Cyclic voltammogram of (i) black chrome and (ii, iii & iv) FeCo (C) NPs modified black chrome selective coatings with varying wt.% of FeCo(C) NPs deposited on copper substrate, recorded with different scan rate (from 5 to 200 mVs^{-1}), in 3.5 wt.% NaCl (saline) solution	56
4.10	Schematic of electrode-solution interphase (electric double layer)	56
4.11	Cyclic voltammogram of (i) black chrome and (ii, iii & iv) FeCo (C) NPs modified black chrome selective coatings with varying wt.% of FeCo(C) NPs deposited on nickel coated copper substrate, recorded with different scan rate (from 5 to 200 mVs^{-1}), in 3.5 wt% NaCl (saline) solution	57
4.12	(Left Panel) Potentiodynamic polarization curve of (i) black chrome and (ii, iii&iv) FeCo(C) NPs modified black chrome solar selective coatings with varying wt.% of FeCo(C) NPs deposited on copper substrates, in 3.5wt.% (Saline) NaCl solution, with varying scan rate (1mVs^{-1} to 100mVs^{-1}). (Right Panel) (Table i, ii, iii&iv) represents the estimated corrosion parameter of black chrome and FeCo(C) NPs modified black chrome selective coatings with varying wt.% of FeCo(C) NPs on copper substrates through Tafel fitting of polarization curves	58
4.13	Corrosion resistance vs. scan rate of black chrome and FeCo(C) NPs modified black chrome with varying wt.% of NPs selective coatings on copper substrates	59
4.14	Percentage weight change as a function of temperature for black chrome and FeCo(C) NPs modified black chrome selective coatings with varying wt.% of NPs deposited on (left) copper and (right) nickel coated copper substrate, in an inert atmosphere	61
4.15	X-ray diffraction spectra of (a&b)(i) black chrome and (a&b)(ii, iii, iv) FeCo(C) NPs modified black chrome selective coatings with varying wt.% of FeCo(C) NPs deposited on copper substrates, (left panel) after Cyclic voltammetry measurements and (right panel) after corrosion measurements	62
4.16	SEM surface micrographs of (a&b)(i) black chrome and (a&b)(ii, iii, iv) FeCo(C) NPs modified black chrome selective coatings with varying wt.% of FeCo(C) NPs deposited on copper substrates, (left panel) after Cyclic voltammetry measurements and (right panel) after corrosion measurements	63

4.17	(left panel) AFM surface morphology of (a)(i) black chrome and (a)(ii, iii, iv) FeCo(C) NPs modified black chrome selective coatings with varying wt.% of FeCo(C) NPs deposited on copper substrates, after Cyclic voltammetry measurements and (right panel) average surface roughness (R_a) with varying wt.% of FeCo(C) NPs	64
4.18	(left panel) AFM surface morphology of (b)(i) black chrome and (b)(ii, iii, iv) FeCo(C) NPs modified black chrome selective coatings with varying wt.% of FeCo(C) NPs deposited on copper substrates, after corrosion measurements and (right panel) average surface roughness (R_a) with varying wt.% of FeCo(C) NPs	65
4.19	EDS elemental analysis of (a)(i) black chrome and (a)(ii, iii, iv) FeCo(C) NPs modified black chrome selective coatings with varying wt.% of FeCo(C) NPs deposited on copper substrates, after cyclic voltammetry measurements	66
4.20	EDS elemental analysis of (b)(i) black chrome and (b)(ii, iii, iv) FeCo(C) NPs modified black chrome selective coatings with varying wt.% of FeCo(C) NPs deposited on copper substrates, after corrosion measurements	66
4.21	reflectance spectra verses wavelength of black chrome and FeCo(C) NPs modified black chrome selective coatings with varying wt.% of FeCo(C) NPs deposited on (a) Cu and (b) nickel coated Cu substrates, after cyclic voltammetry measurements. Calculated absorptance values vs. varying wt.% of FeCo(C) NPs have represented an inset in the graphs a&b	67
4.22	reflectance spectra verses wavelength in the range of 2.5 – 25 μm of black chrome and FeCo(C) NPs modified black chrome with varying wt.% of FeCo(C) NPs selective coatings deposited on (a) copper (b) nickel coated Copper substrates, after cyclic voltammetry measurements. Calculated emittance values vs. varying wt.% of FeCo(C) NPs have represented an inset in the graphs	68
5.1	(a) Schematic representation of $\text{ZrO}_x/\text{ZrC-ZrN/Zr}$ absorber-reflector tandem structures on stainless steel (SS), copper (Cu), aluminum (Al) and glass substrates. (b) Schematic of Zr film growth on SS substrate. with varying deposition time and temperature	70
5.2	X-ray diffraction spectra of the Zr films sputtered at different (a) deposition time and (b) deposition temperature on stainless steel substrates	72
5.3	AFM surface morphology and SEM micrographs images of sputtered deposited Zr thin films on Stainless steel substrate having substrate temperature: (a) RT, (b) 100°C, (c) 200°C, (d) 300°C, (e) 350°C, (f) 400°C, (g) 500°C	74
5.4	Root mean square (RMS) surface roughness and grain size of Zr films deposited on SS substrate at different (a) deposition time and (b) substrate temperature	75
5.5	Film thickness of Zr film on a glass substrate deposited with varying (a) deposition time and (b) substrate temperature	75
5.6	Reflectance spectra of the Zr film deposited on SS substrate (a) with changing time from 30 min to 180 min: in inset show the calculated emittance vs. deposition time. (b) With changing substrate temperature from room temperature to 500°C: in inset show the calculated emittance values vs. substrate temperature	76
5.7	X-ray diffraction spectra of $\text{ZrO}_x/\text{ZrC-ZrN/Zr}$ absorber-reflector tandem structures deposited on SS substrate for all samples prepared under different gas flow conditions a(i) 5sccm S1; a(ii) 6.25sccm S2; a(iii) 8.34sccm S3; a(iv) 10.0sccm S4; a(v) 12.5sccm S5 and a(vi) 16.6sccm S6; and (b) nitride to carbide phase fraction with varying nitrogen flow rates in (i) ZrC-ZrN/Zr/Cu and (ii) ZrC-ZrN/Zr/SS absorbers layers	77
5.8	(Left panel) Raman spectrographs for ZrC-ZrN/Zr structures on SS a(i) and on Cu substrate b(i) and for $\text{ZrO}_x/\text{ZrC-ZrN/Zr}$ structures on SS a(ii) and on Cu substrate b(ii) for S5 sample; and (Right panel) right panel represents Raman spectrographs for all $\text{ZrO}_x/\text{ZrC-ZrN/Zr}$ structures on SS substrates, prepared under different nitrogen flow conditions	78
5.9	(Left panel) Three-dimensional AFM images of Zr layers on SS a(i) substrate; ZrC-ZrN layer deposited on Zr coated SS a(ii) substrate; and $\text{ZrO}_x/\text{ZrC-ZrN/Zr}$ coating deposited on SS a(iii) substrate for S5 sample. (Right Panel) SEM micrographs for the top surface of $\text{ZrO}_x/\text{ZrC-ZrN/Zr}$ absorber-reflector tandem structure on (a) SS (b) Cu substrate	79

5.10	% Reflectance of $ZrO_x/ZrC-ZrN/Zr$ absorber-reflector tandem structures versus wavelength for different samples on SS (a) and Cu (b) substrates; calculated absorptance (α) and emittance (ϵ) values of these $ZrO_x/ZrC-ZrN/Zr$ absorber-reflector tandem structures versus nitrogen flow rates for SS (c) and Cu (d) substrates	81
5.11	Normalized absorptance (α) versus wavelength of $ZrO_x/ZrC-ZrN/Zr$ structure on SS (a) and Cu (b) substrates for S5 sample, in conjunction with AM1.5 solar irradiance as a function of wavelength; and estimated electron concentration in ZrC-ZrN absorbing layer versus nitrogen flow rates for absorber structures on SS (c) and Cu (d) substrates	82
5.12	(Left panel) Effective refractive index and effective extinction coefficient versus wavelength of sequential layers for $ZrO_x/ZrC-ZrN/Zr$ absorber-reflector tandem structures fabricated on SS (a) and (b) substrate. (Right panel) Percentage weight change and first order derivative of weight change as a function of temperature for $ZrO_x/ZrC-ZrN/Zr$ absorber-reflector tandem structures on SS (a) and (b) substrate in air and nitrogen environment	83
5.13	(a) Hardness (H) and Young's modulus (Y) of $ZrO_x/ZrC-ZrN/Zr$ tandem-absorber film on SS substrate and (b) on Al substrate	85
5.14	The load versus displacement curve at difference end loads (a-e) with inset showing the respective AFM indentation profiles and Hardness and Young's modulus values versus load (f) for $ZrO_x/ZrC-ZrN/Zr$ tandem structure with ZrC-ZrN absorber layer synthesized at 12 SCCM nitrogen flow	86
5.15	SEM micrographs of heat treated $ZrO_x/ZrC-ZrN/Zr$ absorber-reflector tandem structure for S5 sample on SS and Cu substrates: a(i) and b(i) as deposited; a(ii) and b(ii) annealed at 700°C/600°C in vacuum and a(iii) and b(iii) annealed at 200°C in the air on SS and Cu substrates respectively	87
5.16	Three-dimensional AFM micrographs of $ZrO_x/ZrC-ZrN/Zr$ absorber-reflector tandem structure for S5 sample on SS and Cu substrate: a(i) and b(i) as deposited; a(ii) and b(ii) annealed at 700°C/600°C in vacuum and a(iii) and b(iii) annealed at 200°C in the air on SS and Cu substrates respectively	88
5.17	% Reflectance versus wavelength for $ZrO_x/ZrC-ZrN/Zr$ absorber-reflector tandem structures: a and b as-deposited, heat-treated at 700°C/600°C in vacuum for 1.5 hours and at 200°C in air for 1 hour for S5 sample on SS and Cu substrate respectively; and c and d absorptance (α) and emittance (ϵ) for as-deposited and heat treated S5 sample on SS and Cu substrate, where acronyms AD, VA, and AA represent as-deposited, vacuum annealed and air annealed samples	88
5.18	(Left Panel) Potentiodynamic polarization curves for (a) bare 304 SS and (b) ARTSSCs ($ZrO_x/ZrC-ZrN/Zr$) deposited on SS substrates, in 3.5 wt.% NaCl solutions, for different scan rates. (Right Panel) Potentiodynamic polarization curves of as-deposited, vacuum and air annealed ARTSSCs ($ZrO_x/ZrC-ZrN/Zr$) deposited on (a) 304 SS and (b) Cu substrates in 3.5 wt.% NaCl solution at scan rate 1 mVs ⁻¹	90
5.19	Variation of (a) Corrosion potential ($E_{corr.}$) and (b) Corrosion current density ($i_{corr.}$) of bare SS and $ZrO_x/ZrC-ZrN/Zr$ absorber-reflector tandem structure coated on SS substrate with varying scan rate	91
5.20	A schematic illustration of electrochemical corrosion attack of $ZrO_x/ZrC-ZrN/Zr$ ARTSSCs on SS substrate in 3.5 wt.% NaCl solution	91
5.21	The load (P) versus displacement curves of corrosion treated AD, AV and AA ARTSSCs coated on SS substrate at load 120 μ N, with inset showing representative AFM nanoindentation areal profile (Left panel); Hardness (H) and Young's modulus (Y) of corrosion treated AD, AV and AA ARTSSCs coated on SS substrate at 120 μ N (Top right panel); Reflectance spectra of corrosion treated as-deposited (AC-AD), vacuum (AC-VA) and air (AC-AA) annealed ARTSSCs coated on SS substrates, in 3.5 wt.% NaCl solution (Bottom right panel)	95
5.22	SEM images of heat treated $ZrO_x/ZrC-ZrN/Zr/SS$ ARTSSCs in (a) N ₂ and (b) air environments up to 900°C	96
5.23	(a) Force Vs. displacement curve at 120 μ N for heat treated $ZrO_x/ZrC-ZrN/Zr/SS$ ARTSSCs in N ₂ and air environments up to 900°C, (b) AFM indentation profile of an indentation, (c) Hardness (H) and (d) Young's Modulus (Y) versus applied force for heat treated $ZrO_x/ZrC-ZrN/Zr/SS$ ARTSSCs in N ₂ and air environment	98
5.24	Reflectance spectra of heat treated $ZrO_x/ZrC-ZrN/Zr/SS$ ARTSSCs structures in N ₂ and air environment up to 900°C	98

A.1	XRD (a) $2\theta/\Omega$ and (b) Ω scans for the (0002) peak of the ZnO NRs grown on Si (100)	104
A.2	(a) FE-SEM image of vertical ZnO nanorod array grown by PLD on a Si (100) substrate. (b) Room temperature photoluminescence spectrum for the ZnO NR grown on Si (100)	105
A.3	(a) Cyclic Voltammetry plots for a ZnO NR/Si (100) working electrode in 1M H_2SO_4 at a 10mV/s scan rate for five cycles. (b) Cyclic voltammetry plots for a ZnO NR / Si (100) working electrode in 8.5M KOH at 10mV/s scan rate for five cycles	105