Contents

CHAPTER 1 TRANSPARENT CONDUCTING COATINGS 1

1.1 Optical Coatings for the Collection and Conservation of Solar Energy, 2

1.2 Metal Films with High Infrared Reflectivity, 2

1.3 Wide Band Gap Semiconductors as Heat Mirrors, 4

1.4 Tin Oxide, 6

1.5 Indium Oxide, 7

1.6 Cadmium Stannate, 11

1.7 Evaluation of Transparent Conductors, 15

1.8 Transparent Heat Mirrors and Selective Absorbers, 15

1.9 Flat-Plate Collectors: Tabor's Concept of a Selective Surface, 16

1.10 Geometrical Spectral Selective Surfaces, 19

CHAPTER 2 APPLICATION OF SELECTIVE SURFACES IN PHOTOTHERMAL CONVERSION 22

2.1 Efficiency of Transparent Filters for Solar Thermal Conversion, 22

2.2 Applications of Selective Coatings in Solar Thermoelectric Generators, 27

2.3 Efficiency of Thermoelectric Generators, 31

2.4 Tabor's Calculations, 33

2.5 The Heat Mirrors as an Alternative to the Selective Absorber, 34

2.6 Testing of Selective Surfaces in a Flat-Plate Collector under Load Conditions, 39

CHAPTER 3 TRANSPARENT CONDUCTORS IN PHOTOVOLTAIC ENERGY CONVERSION 41

3.1 Interfacial Layer Heterojunctions, 42

3.2 SIS Model, 43

3.3 ITO-SnO_2–Si Solar Cells, 46

3.4 *n*-ITO/*p*-CdTe Heterojunctions, 50

3.5 *n*-ITO/*p*-InP Solar Cells, 50

3.6 ITO, SnO_2/GaAs Solar Cells, 51

3.7 $CuInSe_2$/ITO Solar Cells, 52

3.8 Role of Electron Affinity of Oxide Semiconductors as Used in Solar Cells, 52

3.9 Degradation in Transparent Oxide Semiconductor Solar Cells, 56

3.10 Effect of Surface States and Surface Charge, 56

3.11 Future Possibilities of Oxide Semiconductor Solar Cells, 57

CHAPTER 4 CHARACTERIZATION OF SELECTIVE SURFACES 58

4.1 Absorptance and Emittance, 58

4.2 Reflectance, 62

4.3 Relationship among Reflectance, Emittance, Absorptance, and Kirchhoff's Law, 64

4.4 Measurement of Solar Absorptance and Thermal Emittance, 65

4.4.1 Indirect Determination of Solar Absorptance and Thermal Emittance from Reflectance Data, 66

4.4.2 Direct Determination of Thermal Emittance and Solar Absorptance, 73

CHAPTER 5 BLACK SOLAR SELECTIVE SURFACES 88

5.1 Solar Selective Absorbing Surfaces, 89

5.2 Intrinsic Materials, 91

5.3 Absorber–Reflector Tandems, 93

5.3.1 Black Nickel, 95
5.3.2 Black Chrome, 97
5.3.3 Black Copper, 103
5.3.4 Black Iron, 110
5.3.5 Cobalt Oxide, 113
5.3.6 Tungsten Oxide, 114

5.4 Conversion Coatings, 115

5.4.1 Copper Sulfide, 115
5.4.2 Black Zinc Coatings, 116
5.4.3 Colored Stainless-Steel Selective Surfaces, 119
5.4.4 Alcoa 655 Selective Surface, 120

5.5 Pure Semiconductors, 126

5.5.1 Silicon and Germanium, 126
5.5.2 Lead Sulfide, 130

5.6 Metal Silicide and Carbide Solar Selective Surfaces, 134

5.7 Powdered Semiconductor–Reflector Combinations, 139

5.7.1 Semiconductor Pigmented Selective Paints, 139
5.7.2 Inorganic Metal Oxide Pigmented Selective Paints, 142
5.7.3 Organic Black Pigmented Selective Paints, 143
5.7.4 Metal Dust Pigmented Selective Paints, 145

5.8 Multilayer Interference Stacks, 146

5.9 Optical Trapping Systems, 154

5.10 Composite Materials Coatings, 161

5.10.1 Metal–Insulator Composite Films, 162

5.10.2 Semiconductor–Insulator Composite Films, 171

5.11 Dielectric Constant of Composite Selective Surfaces, 177

5.12 Quantum Size Effects, 179

5.13 Selective Surfaces for Concentrating Systems by Magnetron Sputtering, 182

5.14 Performance of Honeycomb Solar–Thermal Converters, 184

CHAPTER 6 CONCLUSION AND RECOMMENDATIONS 191

6.1 Transparent Conducting Coatings, 191

6.2 Plated Coatings, 192

6.3 Paint Coatings, 192

6.4 High-Temperature Selective Surfaces, 193

6.5 Magnetron Sputtering, 194

References 195

Author Index 207

Subject Index 213