

# CONTENTS

<b>CHAPTER 22 THERMO-CHEMICAL DIFFUSION PROCESSES</b>	<b>579</b>
22.1 INTRODUCTION	579
22.2 DIFFUSION PROCESSES	579
22.2.1 LATTICE DIFFUSION	580
22.2.2 THE RATE OF DIFFUSION AND DIFFUSION DEPTH	581
22.2.3 DIFFUSION REMEDY	583
22.3 CARBURIZING (DIFFUSION OF CARBON)	584
22.3.1 VACUUM CARBURIZING	591
22.4 CARBONITRIDING	591
22.5 NITRIDING	595
22.5.1 PLASMA NITRIDING	598
22.5.2 EXPANDED LATTICE S-PHASE	598
22.5.3 NITROCARBURIZING	600
22.6 BORONIZING (BORIDING)	602
22.6.1 BORONIZING PROCESSES	603
22.6.2 INFLUENCE OF THE SUBSTRATE MATERIAL	604
22.6.3 PROCESS PARAMETERS	605
22.6.4 PROPERTIES OF BORONIZED COMPONENTS	606
22.7 CHROMIZING	607
22.8 SHERARDIZING	608
22.9 DIFFUSION ANNEALING	609
22.10 THE TOYOTA DIFFUSION PROCESS	612
22.11 INDUCTION HARDENING	614
22.12 RECOMMENDED ADDITIONAL READING	617
22.13 RELEVANT STANDARDS	617
<b>CHAPTER 23 HOT DIP GALVANIZING</b>	<b>621</b>
23.1 INTRODUCTION	621
23.2 REGULAR HOT DIP GALVANIZING	622
23.2.1 DRY GALVANIZING	622
23.2.2 WET GALVANIZING	624
23.3 GALVANIZING OF SHEETS	625
23.4 REACTIONS BETWEEN IRON AND ZINC	626
23.5 SIGNIFICANT PROCESS PARAMETERS	627

23.5.1	HOT ROLLED CONSTRUCTION STEELS	630
23.5.2	COLD ROLLED STEELS	631
23.5.3	OTHER STEEL TYPES	632
23.6	<b>DECORATIVE COATINGS</b>	633
23.7	<b>THE PROPERTIES OF HOT DIP GALVANIZED STEEL</b>	635
23.8	<b>CONSTRUCTION CONSIDERATIONS</b>	636
23.9	<b>STANDARDS</b>	639
23.10	<b>REFERENCES</b>	640
23.11	<b>RECOMMENDED ADDITIONAL READING</b>	641
23.12	<b>RELEVANT STANDARDS</b>	641
<b>CHAPTER 24</b>	<b>VITREOUS ENAMEL</b>	<b>643</b>
24.1	<b>INTRODUCTION</b>	643
24.2	<b>PROPERTIES AND STRUCTURE</b>	644
24.3	<b>MANUFACTURING OF ENAMELLED PRODUCTS</b>	649
24.3.1	APPLICATION OF ENAMEL	650
24.4	<b>QUALITY SPECIFICATIONS AND TEST METHODS</b>	651
24.5	<b>RECOMMENDED ADDITIONAL READING</b>	651
24.6	<b>RELEVANT STANDARDS</b>	651
<b>CHAPTER 25</b>	<b>THERMAL SPRAYING AND HARDFACING</b>	<b>655</b>
25.1	<b>INTRODUCTION</b>	655
25.2	<b>DIFFERENT TYPES OF THERMAL SPRAYING</b>	657
25.2.1	FLAME SPRAYING	658
25.2.2	ARC SPRAYING	659
25.2.3	DETONATION SPRAYING	660
25.2.4	HIGH VELOCITY OXYGEN FUEL SPRAYING	661
25.2.5	PLASMA SPRAYING	662
25.2.6	COLD SPRAYING	665
25.2.7	COMPARISON OF THERMAL SPRAYING PROCESSES	667
25.2.8	APPLICATION OF THERMAL SPRAYING	672
25.3	<b>LASER FUSING</b>	674
25.4	<b>HARDFACING</b>	676
25.5	<b>REFERENCES</b>	686
25.6	<b>RECOMMENDED ADDITIONAL READING</b>	686
25.7	<b>RELEVANT STANDARDS</b>	687

<b>CHAPTER 26 MECHANICAL PLATING</b>	<b>689</b>
26.1 INTRODUCTION	689
26.2 THE PLATING PROCESS	690
26.2.1 MECHANICAL PLATING OF STEEL	691
26.3 REFERENCES	695
26.4 RECOMMENDED ADDITIONAL READING	695
26.5 RELEVANT STANDARDS	695
<b>CHAPTER 27 INTRODUCTION TO PAINT</b>	<b>697</b>
27.1 INTRODUCTION	697
27.1.1 KEY FACTORS FOR THE SUCCESSFUL USE OF PAINT	700
27.2 THE COMPONENTS OF PAINT	701
27.2.1 BINDERS	701
27.2.2 SOLVENTS	702
27.2.3 PIGMENTS	704
27.2.4 ADDITIVES	742
27.2.5 RHEOLOGY	743
27.3 PRODUCTION OF PAINT	744
27.4 REFERENCES	748
27.5 RECOMMENDED ADDITIONAL READING	749
27.6 RELEVANT STANDARDS	749
<b>CHAPTER 28 CLASSIFICATION OF PAINTS</b>	<b>751</b>
28.1 INTRODUCTION	751
28.2 PHYSICALLY DRYING PAINTS	753
28.2.1 GENERIC PROPERTIES OF PHYSICALLY DRYING PAINTS	753
28.2.2 TAR AND BITUMEN	754
28.2.3 CHLORINATED RUBBER	756
28.2.4 ACRYLIC	758
28.2.5 VINYL	759
28.2.6 NITROCELLULOSE	761
28.3 WATER-BORNE PAINTS	763
28.3.1 GENERIC PROPERTIES OF WATER-BORNE PAINTS	763
28.4 CHEMICALLY CURING PAINTS	766
28.4.1 GENERIC PROPERTIES OF CHEMICALLY CURING PAINTS	766
28.4.2 OXIDATIVELY CURING PAINTS	767
28.4.3 TWO-COMPONENT CURING PAINTS	772
28.4.4 HUMIDITY CURING PAINTS	779
28.4.5 HEAT CURING PAINTS	783

<b>28.5</b>	<b>ALTERNATIVE CURING METHODS</b>	<b>787</b>
28.5.1	ACID-CURING PAINTS	787
28.5.2	PEROXIDE-CURING PAINTS	787
28.5.3	UV-CURING PAINTS	787
<b>28.6</b>	<b>REFERENCES</b>	<b>791</b>
<b>28.7</b>	<b>RECOMMENDED ADDITIONAL READING</b>	<b>791</b>
<b>28.8</b>	<b>RELEVANT STANDARDS</b>	<b>792</b>
 <b>CHAPTER 29 SPECIAL PAINTS AND APPLICATION METHODS</b>		 <b>795</b>
<b>29.1</b>	<b>INTRODUCTION</b>	<b>795</b>
<b>29.2</b>	<b>PAINT FOR CORROSION PREVENTION</b>	<b>795</b>
29.2.1	THE BARRIER EFFECT	796
29.2.2	THE INHIBITING EFFECT	798
29.2.3	THE GALVANIC EFFECT (CATHODIC PROTECTION)	798
29.2.4	DIP-SPIN COATINGS	800
<b>29.3</b>	<b>FOULING CONTROL PAINT</b>	<b>801</b>
<b>29.4</b>	<b>PASSIVE FIRE PROTECTION PAINT</b>	<b>806</b>
<b>29.5</b>	<b>SHOPPRIMERS</b>	<b>809</b>
<b>29.6</b>	<b>ELECTROCOATING PROCESSES</b>	<b>811</b>
29.6.1	ANAPHORESIS	811
29.6.2	CATAPHORESIS	813
29.6.3	CHARACTERISTICS OF THE ELECTROCOATING PROCESS	814
29.6.4	PROCESS CONSIDERATIONS FOR ELECTROCOATING	815
<b>29.7</b>	<b>AUTOPHORETIC LACQUERING PROCESSES</b>	<b>818</b>
<b>29.8</b>	<b>COIL-COATING PROCESSES</b>	<b>820</b>
<b>29.9</b>	<b>POWDER COATING PROCESSES</b>	<b>825</b>
29.9.1	THERMOSETTING POWDER	828
29.9.2	THERMOPLASTIC POWDER	831
29.9.3	APPLICATION METHODS	831
<b>29.10</b>	<b>REFERENCES</b>	<b>838</b>
<b>29.11</b>	<b>RECOMMENDED ADDITIONAL READING</b>	<b>838</b>
 <b>CHAPTER 30 PRETREATMENT PRIOR TO APPLICATION OF PAINT</b>		 <b>841</b>
<b>30.1</b>	<b>INTRODUCTION</b>	<b>841</b>
30.1.1	SURFACE CONTAMINANTS	841
30.1.2	PRELIMINARY CLEANING METHODS	843
<b>30.2</b>	<b>SANDBLASTING METHODS</b>	<b>843</b>
30.2.1	VACUUM BLASTING	845

30.3	<b>WET BLASTING METHODS</b>	846
30.3.1	WATER CLEANING METHODS (WATER JETTING)	847
30.4	<b>ABRASIVE MEDIA</b>	850
30.5	<b>STANDARDS</b>	854
30.6	<b>EVALUATION OF SURFACE ROUGHNESS</b>	859
30.7	<b>PREPARATION OF METAL SURFACES BEYOND STEEL</b>	860
30.7.1	ALUMINUM	860
30.7.2	HOT DIP GALVANIZED STEEL	861
30.7.3	STAINLESS STEEL	861
30.8	<b>PAINT ADHESION</b>	862
30.8.1	SURFACE TENSION AND WETTING	862
30.8.2	ADHESION THEORIES	865
30.9	<b>REFERENCES</b>	867
30.10	<b>RECOMMENDED ADDITIONAL READING</b>	867
30.11	<b>RELEVANT STANDARDS</b>	868
<b>CHAPTER 31</b>	<b>SELECTION OF PAINT SYSTEMS</b>	<b>871</b>
31.1	<b>INTRODUCTION</b>	871
31.2	<b>CORROSION CLASSES</b>	873
31.3	<b>PAINT SYSTEMS FOR CORROSION PROTECTION</b>	875
31.3.1	CONVERSION COATINGS AS PRETREATMENT	880
31.4	<b>TEST OF ORGANIC COATINGS</b>	886
31.5	<b>PAINT DEFECTS</b>	887
31.6	<b>RELEVANT STANDARDS</b>	888
<b>CHAPTER 32</b>	<b>MEASUREMENT OF »TOTAL VISUAL APPEARANCE«</b>	<b>893</b>
32.1	<b>INTRODUCTION</b>	893
32.2	<b>GLOSS</b>	896
32.2.1	HAZE	901
32.3	<b>COLOR</b>	902
32.3.1	COLOR FORMATION	903
32.3.2	MIXING OF COLORS	905
32.4	<b>REFERENCES</b>	912
32.5	<b>RECOMMENDED ADDITIONAL READING</b>	912
32.6	<b>RELEVANT STANDARDS</b>	912

<b>CHAPTER 33</b>	<b>QC; THICKNESS AND ADHESION OF COATINGS</b>	<b>915</b>
33.1	INTRODUCTION	915
33.2	MEASURING THE THICKNESS OF COATINGS	916
33.2.1	WEIGHT GAIN UPON COATING	919
33.2.2	MECHANICAL MEASUREMENT	920
33.2.3	CHEMICAL MEASUREMENT	921
33.2.4	OPTICAL MEASUREMENT	921
33.2.5	ELECTROCHEMICAL MEASUREMENT	926
33.2.6	MAGNETIC MEASUREMENT	929
33.2.7	MAGNETIC-INDUCTIVE MEASUREMENT	930
33.2.8	EDDY-CURRENT MEASUREMENT	931
33.2.9	X-RAY FLUORESCENCE MEASUREMENT	933
33.2.10	BETA BACKSCATTER MEASUREMENT	936
33.2.11	ULTRASONIC MEASUREMENT	937
33.2.12	ELLIPSOMETRY	938
33.2.13	MEASUREMENT BEFORE CURING	939
33.3	QUANTIFYING COATING ADHESION	940
33.3.1	BENDING TEST	941
33.3.2	POLISHING TEST	943
33.3.3	CHISEL TEST	943
33.3.4	PULL TEST	943
33.3.5	FILE TEST	943
33.3.6	GRIND/SAW TEST	944
33.3.7	COOLING TEST	944
33.3.8	IMPACT/STROKE TEST	945
33.3.9	PEEL TEST	945
33.3.10	PUSH TEST	945
33.3.11	SCRIBE/GRID TEST	945
33.3.12	SCRATCH TESTER	948
33.3.13	DAIMLER-BENZ TEST	949
33.4	RELEVANT STANDARDS	951
<b>CHAPTER 34</b>	<b>MEASURING HARDNESS</b>	<b>955</b>
34.1	INTRODUCTION	955
34.2	HARDNESS MEASUREMENT	955
34.2.1	MODELS FOR CORRELATING INDENTER AREA AND SURFACE HARDNESS	959
34.3	NANOINDENTATION	962

<b>CHAPTER 35 CORROSION EVALUATION AND DURABILITY TESTING</b>	<b>965</b>
35.1 INTRODUCTION	965
35.2 CORROSION AND DURABILITY TESTING	967
35.2.1 FIELD TESTING/WEATHERING	967
35.2.2 ACCELERATED LABORATORY TESTING	976
35.3 ADDITIONAL READING	996
35.4 RELEVANT STANDARDS	997
<b>CHAPTER 36 CHARACTERIZATION OF SURFACES AND BULK MATERIALS</b>	<b>1001</b>
36.1 INTRODUCTION	1001
36.2 THE INTERACTION OF ELECTRONS WITH MATTER	1003
36.3 THE INTERACTION OF PHOTONS WITH MATTER	1004
36.3.1 THE LOW ENERGY REGIME	1004
36.3.2 THE INTERMEDIATE ENERGY REGIME	1004
36.3.3 HIGH ENERGY REGIME	1005
36.4 OVERVIEW OF DIFFERENT ANALYSIS TECHNIQUES	1006
36.5 ELECTRON MICROSCOPES AND RELATED TECHNIQUES	1008
36.5.1 THE INTERACTION OF ELECTRONS WITH MATTER	1009
36.5.2 ELECTRON WAVE DUALISM	1012
36.5.3 INTRODUCTION TO SEM/TEM TECHNIQUES	1015
36.5.4 SCANNING ELECTRON MICROSCOPY	1018
36.5.5 SCANNING CONFOCAL ELECTRON MICROSCOPY	1021
36.5.6 REFLECTION ELECTRON MICROSCOPY	1023
36.5.7 SCANNING TRANSMISSION ELECTRON MICROSCOPY	1025
36.5.8 LOW-VOLTAGE ELECTRON MICROSCOPY	1026
36.5.9 ENVIRONMENTAL SCANNING ELECTRON MICROSCOPY	1026
36.5.10 CRYOGENIC-SEM	1028
36.5.11 FIB-SEM	1029
36.5.12 FIELD EMISSION GUN SCANNING ELECTRON MICROSCOPY	1032
36.5.13 TRANSMISSION ELECTRON MICROSCOPE	1033
36.6 ENERGY-DISPERSIVE X-RAY SPECTROSCOPY	1037
36.7 ELECTRON ENERGY LOSS SPECTROSCOPY	1040
36.8 X-RAY PHOTOELECTRON SPECTROSCOPY	1044
36.9 GLOW DISCHARGE OPTICAL EMISSION SPECTROSCOPY	1051
36.9.1 BASIC PRINCIPLE OF OPERATION	1051
36.9.2 EXAMPLES OF GDOES PROFILES	1053
36.10 SECONDARY ION MASS SPECTROSCOPY	1056
36.10.1 TIME-OF-FLIGHT SECONDARY ION MASS SPECTROMETRY	1058

<b>36.11 X-RAY CHARACTERIZATION TECHNIQUES</b>	1060
36.11.1 X-RAY DIFFRACTION	1061
36.11.2 X-RAY FLUORESCENCE	1068
<b>36.12 SURFACE AND SUB-SURFACE ANALYSIS BASED ON HIGH ENERGY ION BEAM TECHNIQUES</b>	1070
36.12.1 RUTHERFORD BACKSCATTERING SPECTROSCOPY	1074
36.12.2 PARTICLE INDUCED X-RAY EMISSION	1078
36.12.3 ELASTIC RECOIL DETECTION ANALYSIS	1083
36.12.4 NUCLEAR REACTION ANALYSIS	1084
<b>36.13 SCANNING PROBE MICROSCOPY</b>	1085
36.13.1 SCANNING TUNNELING MICROSCOPY	1086
36.13.2 ATOMIC FORCE MICROSCOPY	1093
<b>36.14 SPECTROSCOPY</b>	1099
36.14.1 ULTRAVIOLET-VISIBLE (UV-VIS) SPECTROSCOPY	1104
36.14.2 INFRARED SPECTROSCOPY (NEAR-IR, MID-IR AND FAR-IR)	1113
36.14.3 RAMAN	1127
36.14.4 ELLIPSOMETRY	1132
<b>APPENDIX A THERMODYNAMIC CONSIDERATIONS</b>	<b>1139</b>
A.1 INTRODUCTION	1139
A.2 ENTHALPY	1139
A.3 ENTROPY	1141
A.4 GIBB'S FREE ENERGY	1144
A.5 REFERENCES	1145
<b>APPENDIX B REFERENCE DATA</b>	<b>1147</b>
B.1 FUNDAMENTAL CONSTANTS	1147
B.2 ELECTROCHEMICAL EQUIVALENTS	1148
<b>APPENDIX C POURBAIX DIAGRAMS</b>	<b>1155</b>
C.1 DIAGRAMS	1164
C.2 REFERENCES	1187
<b>INDEX</b>	<b>1189</b>
<b>THE AUTHORS</b>	<b>1205</b>