

Contents

List of Acronyms	xi
List of Symbols	xxi

Part I Introduction and Overview

1	Introduction	3
2	Structure and Dynamics of Electrochemical Phase Boundaries	7
3	Scope and Limitations of Classical Electrochemical Methods	9
4	Spectroscopy and Surface Analysis at Interfaces Between Condensed Phases	13
	Further Reading	25
	References	26

Part II Methods and Applications

5	Spectroscopy at Electrochemical Interfaces	35
5.1	Optical Spectroscopy in the Visible Range	37
5.1.1	UV-Vis Spectroscopy with Optically Transparent Electrodes	38
5.1.2	External Reflectance Spectroscopy	43
5.1.3	Attenuated Total Reflectance Spectroscopy	45
5.1.4	Luminescence Spectroscopy	47
5.1.5	Fluorescence Spectroscopy	48
5.1.6	Electroreflectance Spectroscopy (ERS)	50
5.1.7	Diffuse Reflectance Spectroscopy	57
5.1.8	Reflection Anisotropy Spectroscopy	58
5.1.9	Photoacoustic Spectroscopy (PAS)	60
5.1.10	Photothermal Spectroscopy (PTS)	62
5.1.11	Circular Dichroism (CD)	64
5.1.12	Near Infrared Spectroscopy	65

5.2	Optical Spectroscopy in the Infrared Range	71
5.2.1	Infrared Transmission Spectroscopy with Thin Layer Cells	74
5.2.2	Infrared Reflection Spectroscopy	75
5.2.3	External Reflection Spectroscopy	76
5.2.4	Attenuated Total Reflection Spectroscopy	91
5.2.5	Surface Enhanced Infrared Absorption Spectroscopy (SEIRAS)	94
5.2.6	Diffuse Reflectance Infrared Spectroscopy (DRIFT)	100
5.2.7	Photothermal Deflection Spectroscopy (PDS)	100
5.2.8	Infrared Emission Spectroscopy	101
5.2.9	Far Infrared Spectroscopy	102
5.2.10	Raman Spectroscopy	103
5.2.11	Surface Raman Spectroscopy (SRS)	104
5.2.12	Surface Enhanced Raman Spectroscopy (SERS)	104
5.2.13	Surface Enhanced Hyper-Raman Spectroscopy (SEHRS)	123
5.2.14	Surface Resonance Raman Spectroscopy (SRRS)	125
5.2.15	Confocal Raman Spectroscopy	128
5.2.16	Near Field Raman Microscopy (Micro-Spectroscopy)	130
5.3	Spectroscopy in the X-ray Range	131
5.3.1	Mössbauer Spectroscopy	131
5.3.2	X-Ray Absorption Spectroscopy	137
5.3.3	X-Ray Absorption Fine Structure Spectroscopy	137
5.4	Magnetic Resonance Spectroscopy	143
	Further Reading	159
5.5	Magneto-optic and Magnetic Methods	159
5.5.1	Magnetic Circular Dichroism	159
5.5.2	Magneto-Optical Kerr Effect (MOKE)	160
5.5.3	Alternating Gradient Field Magnetometry (AGFM)	162
5.5.4	SQUID Magnetometry	163
5.6	Photoelectrochemical Methods	164
5.6.1	Photoemission Spectroscopy	164
5.6.2	Photocurrent Spectroscopy (PCS)	165
5.6.3	Photovoltage Spectroscopy (PVS)	170
5.6.4	Photoluminescence (PL)	171
5.6.5	Micro-Optical Ring Electrode (MORE)	172
5.7	Nonlinear Optical Methods	173
5.7.1	Second Harmonic Generation (SHG)	173
5.7.2	Sum and Difference Frequency Generation	175
5.8	Mass Spectrometry	178
5.8.1	Differential Electrochemical Mass Spectrometry (DEMS)	178
5.8.2	Electrospray Mass Spectrometry	180
5.8.3	Thermospray Mass Spectrometry	182
5.8.4	Inductively Coupled Plasma Mass Spectrometry (ICPMS)	183
5.8.5	Thermodesorption Mass Spectrometry (TDMS)	183

5.9	Miscellaneous Spectroscopies and Methods	184
5.9.1	Probe beam deflection (PBD)	184
5.9.2	Light Reflection Method	189
5.9.3	Phase-Shift Interferometry	190
5.9.4	Photoacoustic Methods	190
5.9.5	Ellipsometry	192
5.9.6	Surface Plasmon Resonance Spectroscopy	195
5.9.7	Surface Plasmon Excitation and Related Methods	199
5.9.8	Inductively Coupled Plasma Atomic Emission Spectroelectrochemistry	200
5.9.9	Positron Annihilation Spectroscopy (PAS)	201
5.9.10	Neutron Reflectivity	202
5.9.11	Neutron Scattering	203
	References	204
6	Diffraction and Other X-Ray Methods	233
6.1	X-Ray Diffraction Methods	233
6.1.1	X-Ray Diffraction	234
6.1.2	Surface X-Ray Diffraction (SXD)	239
6.1.3	Surface Differential X-Ray Diffraction (SDD)	240
6.1.4	Neutron Diffraction	240
6.2	Miscellaneous Methods	241
6.2.1	X-ray Standing Wave Fluorescence Analysis (XSW)	241
6.2.2	Surface X-ray Scattering (SXS)	242
6.2.3	Small Angle X-ray Scattering (SAXS)	245
6.2.4	Specular X-ray Reflection	246
	References	247
7	Surface Analytical Methods	251
7.1	Topographic Methods	251
7.2	Scanning Probe Methods	252
7.2.1	Scanning Tunneling Microscopy (STM)	253
7.2.2	Differential Conductance Tunneling Spectroscopy (DCTS)	260
7.2.3	Atomic Force Microscopy (AFM)	260
7.2.4	Scanning Kelvin Probe Force Microscopy (SKPFM)	263
7.2.5	Scanning Electrochemical Microscopy (SECM)	264
7.2.6	pH-Microscopy	270
7.2.7	Scanning Ion-Conductance Microscopy	271
7.2.8	Scanning Reference Electrode Technique (SRET)	271
7.2.9	Scanning Vibrating Electrode Technique (SVET)	272
7.2.10	Scanning Kelvin Probe (SKP)	273
7.2.11	Scanning Tunneling Spectroscopy and Related Methods	277
7.3	Near Field and Confocal Optical Methods	279
7.3.1	Near Field Methods	280
7.3.2	Confocal Optical Methods	280

7.4	Surface Conductivity Measurements	281
7.5	Interfacial Conductivity Measurements	285
7.6	Microradiology	286
	References	286
Index	295