



Table of Contents

Preface	ix
Acknowledgments	xi
Introduction	1
I Concepts	3
Chapter 1 • The history of photoemission	5
1.1 Origin of photoemission: the photoelectric effect	6
1.2 Core level spectroscopy	9
1.3 Band structure	12
1.4 Photoemission: a standard technique for the study of electronic properties	13
Chapter 2 • Elementary approach to photoemission	17
2.1 The photoelectron emission process	17
2.2 Technical aspects of a photoemission experiment	21
2.3 Model to describing the photoemission process	23
2.4 The core levels	23
2.5 The valence band	26
Chapter 3 • Basic concepts	29
3.1 Photoemission modelling	29

3.1.1	Hamiltonian of the electron-photon interaction Hamiltonian and transition probability	29
3.1.2	Qualitative approach: nearly-free electrons	33
3.1.3	Qualitative approach: core levels	42
3.1.4	The one-step and the three-step models	47
3.1.5	The three-step model	48
3.2	Detailed analysis of valence states: N-body approach.	56
3.2.1	Fermi liquid and quasi-particles.	56
3.2.2	Many-body formalism	57
3.2.3	Illustrations.	68
3.2.4	Selection rules and symmetry	72
3.2.5	Matrix elements.	76
3.2.6	Temperature dependence	86
3.3	Detailed analysis of core levels	90
3.3.1	Core level line shape in metals	91
3.3.2	Multiplet effects	94
3.3.3	Satellite structures	97
3.3.4	Selection rules for core level photoemission	102
3.3.5	Cross section	103
3.4	Related processes	106
3.4.1	Auger spectroscopy	106
3.4.2	Photoelectron diffraction	109
3.4.3	Resonant photoemission	114
3.4.4	Two-photon processes	120
3.4.5	Inverse photoemission	123
Chapter 4	• Experimental techniques	129
4.1	Ultra-high vacuum	129
4.2	Micromechanics	131
4.3	Photon sources	132
4.3.1	Discharge lamps	132
4.3.2	X-ray tubes	134
4.3.3	Laser photoemission: ultra-high resolution and dynamical studies	136

4.3.4	Synchrotron radiation and beam lines	140
4.3.5	Free electron lasers	153
4.4	Electron analyzers	155
4.4.1	Cylindrical Mirror Analyzer	158
4.4.2	Hemispherical Analyzer	159
4.4.3	Toroidal detectors	161
4.4.4	High pressure electron detection	162
4.4.5	Time-of-flight detector	162
4.4.6	Spin analyzers	164
4.4.7	Photoemission microscope	167
II Applications		171
Chapter 5	• Transitions from localized states	173
5.1	Spectral shape of core level transitions	174
5.1.1	Auger transitions	174
5.1.2	Photoemission transitions	176
5.1.3	Spectra from complex core levels	180
5.2	Core level spectroscopy applications	186
5.2.1	Quantitative chemical analysis	186
5.2.2	Chemical shifts	188
5.2.3	Composition profile under the surface	192
5.2.4	Coverage estimation	193
5.2.5	Growth kinetics	194
5.2.6	Dichroism in photoemission	196
Chapter 6	• Photoelectron diffraction	199
6.1	Experimental techniques	199
6.2	Methods for structural determination	201
6.2.1	Direct methods	201
6.2.2	Comparative methods	204
6.3	Photoelectron diffraction examples	209
Chapter 7	• Dispersion relations	217
7.1	Experimental data representation	218

A Primer in Photoemission: Concepts and Applications

7.1.1	Two-dimensional representations of the dispersion	218
7.1.2	Energy and Momentum Distribution Curves	220
7.1.3	Positive-negative energy symmetrization of the data	223
7.1.4	Normalizations to study states near the Fermi level	224
7.1.5	Fermi surface representation	226
7.1.6	Transport	229
7.2	Spectral signature analysis	230
7.2.1	Electron-phonon coupling	230
7.2.2	k perpendicular determination	234
7.2.3	Spin polarisation	235
7.2.4	Final-state and matrix element effects	238
7.2.5	Other applications	240
A Photoemission with a detection slit parallel to the polar rotation		247
B Quality of a core level fit		251
C Fermi level determination		255
D Acronyms		259
Index		261