
Contents – Volume VI

11	Scanning Tunneling Microscopy of Physisorbed Monolayers: From Self-Assembly to Molecular Devices	
	<i>Thomas Müller</i>	1
11.1	Introduction	1
11.2	Source of Image Contrast: Geometric and Electronic Factors . . .	2
11.3	Two-Dimensional Self-Assembly: Chemisorbed and Physisorbed Systems	4
11.4	Self-Assembly on Graphite	6
11.4.1	Alkane Functionalization and Driving Forces for Self-Assembly .	6
11.4.2	Expression of Chirality	11
11.5	Beyond Self-Assembly	14
11.5.1	Postassembly Modification	14
11.5.2	Templates for Bottom-Up Assembly	21
11.6	Toward Molecular Devices	23
11.6.1	Ring Systems and Electronic Structure	23
11.6.2	Model Systems for Molecular Electronics	25
11.7	Summary and Conclusions	28
	References	28
12	Tunneling Electron Spectroscopy Towards Chemical Analysis of Single Molecules	
	<i>Tadahiro Komeda</i>	31
12.1	Introduction	31
12.2	Vibrational Excitation Through Tunneling Electron Injection . . .	32
12.2.1	Characteristic Features of the Scanning Tunneling Microscope as an Electron Source	32
12.2.2	Electron-Induced Vibrational Excitation Mechanism	33
12.3	IET Process of Vibrational Excitation	36
12.3.1	Basic Mechanism of Vibrational Excitation in the IET Process . .	37

12.3.2	IETS with the Setup of STM	39
12.3.3	Instrumentation of IETS with the Use of STM	40
12.3.4	Examples of STM-IETS Measurements	41
12.3.5	Theoretical Treatment of STM-IETS Results	44
12.3.6	IETS Mapping	48
12.4	Manipulation of Single Molecule Through Vibrational Excitation .	49
12.4.1	Desorption via Vibrational Excitation	49
12.4.2	Vibration-Induced Hopping	51
12.4.3	Vibration-Induced Chemical Reaction	54
12.5	Action Spectroscopy	55
12.5.1	Rotation of <i>cis</i> -2-Butene Molecules	56
12.5.2	Complimentary Information of Action Spectroscopy and IETS . .	57
12.6	Conclusions	60
	References	61
13	STM Studies on Molecular Assembly at Solid/Liquid Interfaces	
	<i>Ryo Yamada, Kohei Uosaki</i>	65
13.1	Introduction	65
13.2	STM Operations in Liquids	66
13.2.1	Instruments	66
13.2.2	Preparation of Substrates	67
13.3	Surface Structures of Substrates	68
13.3.1	Introduction	68
13.3.2	Structures of Au(111)	68
13.3.3	Structures of Au(100)	68
13.4	SA of Organic Molecules	69
13.4.1	Introduction	69
13.4.2	Assembly of Chemisorbed Molecules: Alkanethiols	70
13.4.3	Assembly of Physisorbed Molecules: <i>n</i> -Alkanes	80
13.5	SA of Inorganic Complexes	84
13.5.1	Introduction	84
13.5.2	Assembly of Metal Complexes	85
13.5.3	Assembly of Metal Oxide Clusters: Polyoxometalates	92
13.6	Conclusions	96
	References	96

14	Single-Molecule Studies on Cells and Membranes Using the Atomic Force Microscope	
	<i>Ferry Kienberger, Lilia A. Chitchevlova, Andreas Ebner, Theeraporn Puntheeranurak, Hermann J. Gruber, Peter Hinterdorfer</i>	101
14.1	Abstract	101
14.2	Introduction	102
14.3	Principles of Atomic Force Microscopy	103
14.4	Imaging of Membrane–Protein Complexes	104
14.4.1	Membranes of Photosynthetic Bacteria and Bacterial S-Layers . .	104
14.4.2	Nuclear Pore Complexes	106
14.4.3	Cell Membranes with Attached Viral Particles	106
14.5	Single-Molecule Recognition on Cells and Membranes	110
14.5.1	Principles of Recognition Force Measurements	110
14.5.2	Force-Spectroscopy Measurements on Living Cells	113
14.6	Unfolding and Refolding of Single-Membrane Proteins	117
14.7	Simultaneous Topography and Recognition Imaging on Cells (TREC)	119
14.8	Concluding Remarks	122
	References	123
15	Atomic Force Microscopy of DNA Structure and Interactions	
	<i>Neil H. Thomson</i>	127
15.1	Introduction: The Single-Molecule, Bottom-Up Approach	127
15.2	DNA Structure and Function	129
15.3	The Atomic Force Microscope	131
15.4	Binding of DNA to Support Surfaces	137
15.4.1	Properties of Support Surfaces for Biological AFM	137
15.4.2	DNA Binding to Surfaces	138
15.4.3	DNA Transport to Surfaces	142
15.5	AFM of DNA Systems	143
15.5.1	Static Imaging versus Dynamic Studies	143
15.5.2	The Race for Reproducible Imaging of Static DNA	144
15.5.3	Applications of Tapping-Mode AFM to DNA Systems	146
15.6	Outlook	157
	References	159

16	Direct Detection of Ligand–Protein Interaction Using AFM	
	<i>Małgorzata Lekka, Piotr Laidler, Andrzej J. Kulik</i>	165
16.1	Cell Structures and Functions	166
16.1.1	Membranes and their Components: Lipids and Proteins	166
16.1.2	Glycoproteins	167
16.1.3	Immunoglobulins	169
16.1.4	Adhesion Molecules	170
16.1.5	Plant Lectins	173
16.2	Forces Acting Between Molecules	175
16.2.1	Repulsive Forces	177
16.2.2	Attractive Forces	179
16.3	Force Spectroscopy	181
16.3.1	Atomic Force Microscope	182
16.3.2	Force Curves Calibration	187
16.3.3	Determination of the Unbinding Force	188
16.3.4	Data Analysis	189
16.4	Detection of the Specific Interactions on Cell Surface	193
16.4.1	Isolated Proteins	194
16.4.2	Receptors in Plasma Membrane of Living Cells	196
16.5	Summary	201
	References	202
17	Dynamic Force Microscopy for Molecular-Scale Investigations of Organic Materials in Various Environments	
	<i>Hirofumi Yamada, Kei Kobayashi</i>	205
17.1	Brief Overview	205
17.2	Principles and Instrumentation of Frequency Modulation Detection Mode Dynamic Force Microscopy	206
17.2.1	Transfer Function of the Cantilever as a Force Sensor	206
17.2.2	Detection Methods of Resonance Frequency Shift of the Cantilever	208
17.2.3	Instrumentation of the Frequency Modulation Detection Mode	210
17.2.4	Frequency Modulation Detector	212
17.2.5	Phase-Locked-Loop Frequency Modulation Detector	212
17.2.6	Relationship Between Frequency Shift and Interaction Force	214
17.2.7	Inversion of Measured Frequency Shift to Interaction Force	216
17.3	Noise in Frequency Modulation Atomic Force Microscopy	217
17.3.1	Thermal Noise Drive	217
17.3.2	Minimum Detectable Force in Static Mode	218

17.3.3	Minimum Detectable Force Using the Amplitude Modulation Detection Method	218
17.3.4	Minimum Detectable Force Using the Frequency Modulation Detection Method	219
17.3.5	Effect of Displacement-Sensing Noise on Minimum Detectable Force	220
17.3.6	Comparison of Minimum Detectable Force for Static Mode and Dynamic Modes	223
17.4	High-Resolution Imaging of Organic Molecules in Various Environments	225
17.4.1	Alkanethiol Self-Assembled Monolayers	225
17.4.2	Submolecular-Scale Contrast in Copper Phthalocyanines	228
17.4.3	Atomic Force Microscopy Imaging in Liquids	230
17.5	Investigations of Molecular Properties	233
17.5.1	Surface Potential Measurements	233
17.5.2	Energy Dissipation Measurements	241
17.6	Summary and Outlook	243
	References	244

18 Noncontact Atomic Force Microscopy

	<i>Yasuhiro Sugawara</i>	247
18.1	Introduction	247
18.2	NC-AFM System the Using FM Detection Method	247
18.3	Identification of Subsurface Atom Species	249
18.4	Tip-Induced Structural Change on a Si(001) Surface at 5 K	251
18.5	Influence of Surface Stress on Phase Change in the Si(001) Step at 5 K	252
18.6	Origin of Anomalous Dissipation Contrast on a Si(001) Surface at 5 K	253
18.7	Summary	254
	References	255

19 Tip-Enhanced Spectroscopy for Nano Investigation of Molecular Vibrations

	<i>Norihiko Hayazawa, Yuika Saito</i>	257
19.1	Introduction	257
19.2	TERS (Reflection and Transmission Modes)	258

19.2.1	Experimental Configuration of TERS	258
19.2.2	Transmission Mode	259
19.2.3	Reflection Mode	260
19.3	How to Fabricate the Tips?	261
19.3.1	Vacuum Evaporation and Sputtering Technique	261
19.3.2	Electroless Plating	261
19.3.3	Etching of Metal Wires Followed by Focused Ion Beam Milling	262
19.3.4	Other Methods	263
19.4	Tip-Enhanced Raman Imaging	263
19.4.1	Selective Detection of Different Organic Molecules	264
19.4.2	Observation of Single-Walled Carbon Nanotubes	265
19.5	Polarization-Controlled TERS	268
19.5.1	Polarization Measurement by Using a High NA Objective Lens	268
19.5.2	Metallized Tips and Polarizations	269
19.5.3	Example of <i>p</i> - and <i>s</i> -Polarization Measurements in TERS	271
19.6	Reflection Mode for Opaque Samples	272
19.6.1	TERS Spectra of Strained Silicon	272
19.6.2	Nanoscale Characterization of Strained Silicon	274
19.7	For Higher Spatial Resolution	275
19.7.1	Tip-Pressurized Effect	275
19.7.2	Nonlinear Effect	278
19.8	Conclusion	282
	References	283

20 Investigating Individual Carbon Nanotube/Polymer Interfaces with Scanning Probe Microscopy

	<i>Asa H. Barber, H. Daniel Wagner, Sidney R. Cohen</i>	287
20.1	Mechanical Properties of Carbon-Nanotube Composites	288
20.1.1	Introduction	288
20.1.2	Mechanical Properties of Carbon Nanotubes	288
20.1.3	Carbon-Nanotube Composites	290
20.2	Interfacial Adhesion Testing	292
20.2.1	Historical Background	292
20.2.2	Shear-Lag Theory	293
20.2.3	Kelly–Tyson Approach	294
20.2.4	Single-Fiber Tests	294
20.3	Single Nanotube Experiments	296
20.3.1	Rationale and Motivation	296
20.3.2	Drag-out Testing (Ex Situ Technique)	297
20.3.3	Pull-out Testing (In Situ)	298

20.3.4	Comparison of In Situ and Ex Situ Experiments	304
20.3.5	Wetting Experiments	306
20.4	Implication of Results and Comparison with Theory	311
20.4.1	Interfaces in Engineering Composites	311
20.4.2	Simulation of Carbon-Nanotube/Polymer Interfacial Adhesion Mechanisms	312
20.4.3	Discussion of Potential Bonding Mechanisms at the Interface . . .	314
20.5	Complementary Techniques	314
20.5.1	Raman Spectroscopy	314
20.5.2	Scanning Electron Microscopy	316
20.5.3	Overall Conclusions	320
References		320
Subject Index		325



<http://www.springer.com/978-3-540-37318-6>

Applied Scanning Probe Methods VI
Characterization

Bhushan, B.; Kawata, S. (Eds.)

2007, XLV, 338 p., Hardcover

ISBN: 978-3-540-37318-6