

Contents

Acknowledgements	iv
Abstract	v
1 Introduction	1
2 Apparatus	7
2.1 UHV chamber system	7
2.2 Electron gun system	14
2.3 Imaging system	18
2.4 Sample translation and manipulation	19
2.5 Gas-handling system	22
2.6 Femtosecond laser system	26
3 Methodology	30
3.1 Electron crystallography	30
3.2 Pump-probe experiment	39
3.2.1 Characterization of the electron pulses	41
3.2.2 Alignment of the laser and electron beams	44
3.2.3 Measuring the laser fluence on the sample	45
3.2.4 Determining time resolution and time zero	46
3.3 Analysis of the diffraction patterns	48
4 Studies of Single-Crystal Surfaces with Small Adsorbates	51
4.1 Silicon(111) surface	52

4.2	GaAs(111) surface	58
4.3	Surfaces with adsorbates	68
5	Fatty Acid and Phospholipid Crystalline Adsorbates:	
	Steady State Studies	70
5.1	Langmuir-Blodgett films of fatty acids and phospholipids	71
5.2	Preparation of layers by LB deposition	74
5.3	Fatty acid bilayers structure	77
5.4	Fatty acid bilayers temperature-dependent structural change	84
5.5	Fatty acid multilayers structure	88
5.6	Phospholipid monolayer and bilayer structure	92
6	Fatty Acid and Phospholipid Crystalline Adsorbates:	
	Ultrafast T-jump Dynamics	94
6.1	Fatty acids structural dynamics	95
6.1.1	Atomic motions in the chain	98
6.1.2	Transient structural ordering	105
6.1.3	Dynamics at different static temperature	108
6.2	Phospholipid structural dynamics	109
6.3	Structural dynamics picture	113
7	Conclusion	117
	Bibliography	121

List of Figures

2.1	The chamber system with frame support.	8
2.2	Schematic diagram of the experimental setup.	10
2.3	Schematic side view of the sample preparation chamber and the load-lock chamber.	13
2.4	Schematic view of the goniometer.	15
2.5	A cut through the electron gun chamber and the scattering chamber.	16
2.6	A cut through the CCD imaging system.	18
2.7	Schematic side view of the load lock chamber and the scattering chamber.	21
2.8	Schematic view of the gas-handling system.	23
2.9	The optics layout.	28
3.1	Schematic diagrams of Ewald sphere construction.	35
3.2	Schematic diagram of RHEED experiment.	37
3.3	Schematic view of the experiment.	40
3.4	Electric diagram for the streaking experiment.	42
3.5	Result of the streaking experiment.	43
3.6	Schematic diagram of the alignment.	44
3.7	Schematic diagram of the measurement of excitation laser beam spatial profile.	47
4.1	Structure of the Si:H(111) crystal.	52
4.2	Diffraction patterns of Si(111) surfaces.	53
4.3	The temporal change of the Bragg spot (-4,7).	55
4.4	UEC of phase transition of the amorphous to liquid state.	57

4.5	Structure of the GaAs:Cl(111) crystal.	58
4.6	GaAs:Cl(111) surface lattice structure.	59
4.7	Static diffraction images of the GaAs:H(111) surface.	60
4.8	Time dependence of the Bragg reflection center position.	62
4.9	Fluence dependence of the Bragg reflection center position change. . .	63
4.10	Comparison of the integrated intensity, center position and width change of the Bragg spot.	65
5.1	Structure of crystalline adsorbates of fatty acids and phospholipids. . .	73
5.2	Structure of the orthorhombic C ₂ H ₄ subunit cell.	74
5.3	Directions of dipping, observation and subunit cell orientation.	76
5.4	Static diffraction patterns of fatty acid bilayers.	78
5.5	Static diffraction rocking curve of fatty acid bilayers.	79
5.6	Calculated diffraction patterns.	81
5.7	Static temperature dependent diffraction patterns.	85
5.8	Static temperature dependence of diffraction intensity and subunit cell dimensions.	86
5.9	Schematic view of the static thermal behavior.	88
5.10	Multilayer diffraction patterns.	90
5.11	Inclined diffraction patterns for 8-layer samples.	91
5.12	Static diffraction patterns of DMPA samples.	93
6.1	Diffraction difference frames of the (002) Bragg spot.	96
6.2	Full analysis of the (002) Bragg spot.	97
6.3	Time dependence of the peak shift and the corresponding molecular axial length change for bilayers.	99
6.4	Dynamics of fatty acid bilayer compared to that of the substrate Si(111) surface.	100
6.5	Time dependence of the molecular axial length change for 2-, 4- and 8-layer sample.	102
6.6	Dynamics of the inclined 8-layer sample.	104

6.7	Relative intensity change I/I_0 as a function of time for 2-, 4- and 8-layer samples.	105
6.8	Schematic view of the transient structural ordering.	107
6.9	Dependence of the transient dynamics on initial substrate static temperature.	108
6.10	Static diffraction and diffraction difference patterns of DMPA monolayer and bilayer.	110
6.11	The axial change Δc_0 and the normalized integrated intensity of the $(hk2)$ diffraction line as a function of time.	111

List of Tables

5.1	Lattice parameters for fatty acid bilayers.	82
5.2	Lattice parameters for fatty acid multilayers.	89