

# Table of Contents

<b>INTRODUCTION</b>	<b>1</b>
<b>PART I SOLID STATE PHYSICS, ELECTRONICS AND OPTICS</b>	
<b>Section 1 Materials and Fabrication</b>	<b>5</b>
<b>Chapter 1 Submicron Structures Technology and Research</b>	<b>7</b>
<i>Professor Henry I. Smith</i>	
1.1 Submicron Structures Laboratory .....	7
● 1.2 Microfabrication at Linewidths of 100nm and Below .....	7
1.3 Improved Mask Technology For X-Ray Lithography .....	9
● 1.4 Study of Electron Transport in Si MOSFETs with Deep-Submicron Channel Lengths .....	9
● 1.5 Studies of Electronic Conduction in One-Dimensional Semiconductor Devices .....	10
● 1.6 Surface Superlattice Formation in Silicon Inversion Layers Using 0.2 $\mu\text{m}$ -Period Grating-Gate Field-Effect Transistors .....	12
1.7 Study of Surface Superlattice Formation in GaAs/GaAlAs Modulation Doped Field-Effect Transistors .....	13
● 1.8 Study of One-Dimensional Subbands and Mobility Modulation in GaAs/AlGaAs Quantum Wires .....	14
● 1.9 Arrays of Field-Effect-Induced Quantum Dots .....	14
1.10 Planar-Resonant-Tunneling Field-Effect Transistors (PRESTFETs) .....	16
● 1.11 Submicrometer-Period Gold Transmission Gratings for X-Ray Spectroscopy and Atom-Beam Interferometry .....	17
1.12 High-Dispersion, High-Efficiency Transmission Gratings for Astrophysical Spectroscopy .....	17
1.13 Epitaxy via Surface-Energy-Driven Grain Growth .....	18
<b>Chapter 2 Microstructural Evolution in Thin Films of Electronic Materials</b> .....	<b>21</b>
<i>Professor Carl V. Thompson</i>	
● 2.1 Modeling of Microstructural Evolution in Thin Films .....	21
● 2.2 Reliability and Microstructures of Interconnects .....	22
2.3 Epitaxial Grain Growth .....	23
2.4 Heteroepitaxy in Lattice Mismatched Systems .....	24
2.5 Kinetics of Thin Film Silicide Formation .....	24
2.6 Coarsening of Particles on a Planar Substrate .....	25
2.7 Thin Film Zone Melting Recrystallization of Silicon .....	25
2.8 Capillary Instabilities in Thin Solid Films .....	25
2.9 Focused Ion Beam Induced Deposition .....	25
2.10 Protective Coatings for Integrated Circuits in an In Vitro Environment .....	26

Table of Contents

<b>Chapter 3</b>	<b>Focused Ion Beam Fabrication</b> .....	<b>29</b>
	<i>Dr. John Melngailis</i>	
3.1	Focused Ion Beam Fabrication .....	29
3.2	Development of Focused Ion Beam Implantation and Lithography .....	29
3.3	Frequency Tunable Gunn Diodes Fabricated by Focused Ion Beam Implantation .....	30
3.4	NMOS Transistors with Focused Ion Beam Implanted Channel Regions .....	30
3.5	GaAs MESFETs Fabricated with Focused Ion Beam Channel Implants .....	31
3.6	Focused Ion Beam Exposure of Resists .....	31
3.7	Focused Ion Beam Induced Deposition of Low Resistivity Gold Structures .....	31
3.8	Fundamental Properties of Ion Induced Deposition .....	32
3.9	In-Situ Measurement of Gas Adsorption and Ion Induced Deposition .....	32
3.10	Focused Ion Beam Induced Deposition of Platinum .....	33
<b>Chapter 4</b>	<b>Chemical Reaction Dynamics at Surfaces</b> .....	<b>35</b>
	<i>Professor Sylvia T. Ceyer</i>	
● 4.1	Chemical Reaction Dynamics on Semiconductor Surfaces .....	35
4.2	Collision Induced Dissociative Chemisorption of $CH_4$ on Ni(111) by Inert Gas Atoms: The Mechanism for Chemistry with a Hammer .....	36
4.3	Collision Induced Desorption .....	37
4.4	Synthesis of Benzene from Methane .....	38
4.5	The Structure and Chemistry of $CH_3$ and CH Radicals and Isotopic Variants Adsorbed on Ni(111) .....	38
4.6	High Resolution Electron Energy Loss Spectroscopy of H on Ni(111) .....	39
<b>Chapter 5</b>	<b>Measurement of Electron-phonon Interactions Through Large-amplitude Phonon Excitation</b> .....	<b>41</b>
	<i>Professor Keith A. Nelson</i>	
● 5.1	Introduction .....	41
● 5.2	High Repetition-rate Signals and Resonant Responses of Crystalline Solids .....	41
<b>Chapter 6</b>	<b>Chemical Beam Epitaxy of Compound Semiconductors</b> .....	<b>47</b>
	<i>Professor Leslie A. Kolodziejski</i>	
● 6.1	Chemical Beam Epitaxy Facility .....	47
● 6.2	Controlled Substitutional Doping of ZnSe Grown by Chemical Beam Epitaxy .....	49
6.3	Laser-Assisted Chemical Beam Epitaxy of Wide Bandgap Blue/Green II-VI Semiconductors .....	50
<b>Chapter 7</b>	<b>High-Frequency InAlAs/InGaAs Metal-Insulator-Doped Semiconductor Field-Effect Transistors (MIDFETs) for Telecommunications</b> .....	<b>53</b>
	<i>Professor Jesus A. del Alamo</i>	
● 7.1	Introduction .....	53
● 7.2	Experiments .....	54
● 7.3	Device Results .....	54
<b>Chapter 8</b>	<b>Novel Superconducting Tunneling Structures</b> .....	<b>59</b>
	<i>Professor John M. Graybeal</i>	
● 8.1	Project Description .....	59

<b>Chapter 9</b>	<b>Heterostructures for High Performance Devices</b>	<b>61</b>
	<i>Professor Clifton G. Fonstad, Jr.</i>	
9.1	Introduction	61
● 9.2	Computer Controlled Growth of Lattice-Matched InGaAlAs Heterostructures on InP	61
9.3	InGaAlAs Multiple Quantum Well Heterostructures for Guided Wave Optics	62
9.4	MBE-Grown InGaAlAs/InP Long-Wavelength Laser Diodes for Narrow Linewidth Applications	63
● 9.5	InGaAlAs Strained-Layer Heterostructures on 111 GaAs and InP for Optical for Modulator Applications	64
9.6	Molecular Beam Epitaxial Growth on (h11) Vicinal Surfaces	65
● 9.7	Pseudomorphic AlAs/InAs/InGaAs Resonant Tunneling Structures	65
● 9.8	Three-Terminal Quantum Well Base/Tunnel Barrier Devices	66
9.9	Design and Fabrication of GaAlAs Heterostructure Laser Diodes for Monolithic Integration with Si Circuits	66
9.10	Microbridge Suspension of Monolithic GaAlAs Heterostructures Grown on Si by MBE	67
9.11	Damage-Free In-Situ UHV Etching and Cleaning of III-V Heterostructures Using Molecular Beams	68
<b>Section 2</b>	<b>Optics and Devices</b>	<b>71</b>
<b>Chapter 1</b>	<b>Optics and Quantum Electronics</b>	<b>73</b>
	<i>Professor Hermann A. Haus, Professor Erich P. Ippen, Professor James G. Fujimoto, Professor Peter L. Hagelstein, Dr. Santanu Basu, Dr. Jyhpyng Wang</i>	
● 1.1	The Nonlinear Waveguide Interferometer	73
1.2	Picosecond Optical Signal Sampling	74
● 1.3	Nonlinear Dynamics in Active Semiconductor Waveguides	75
● 1.4	Saturation Characteristics of Semiconductor Optical Amplifiers	76
● 1.5	Femtosecond Studies of Metallic and High Tc Superconductors	76
● 1.6	Suppressed and Enhanced Spontaneous Emission from Microcavities	77
● 1.7	New Ultrashort Pulse Laser Technology	78
● 1.8	Ultrafast Processes in Waveguide Devices	80
● 1.9	Image Potential and Electron Dynamics in Metals	82
1.10	Laser Medicine	83
1.11	Developmental Status of a Table-top XUV Laser at 194 Angstrom	86
1.12	Status of Zig-zag Slab Laser Development	88
1.13	Whisper Gallery Mirror Design	89
1.14	Polarizing Cavities for the Extreme Ultraviolet	90
1.15	Unstable Resonators for XUV Lasers	92
1.16	Advances in Conjugate Gradient Algorithm Development	93
1.17	Frequency Upconversion of Extreme UV Radiation	94
1.18	X-ray Detectors Based on the Quantum Well Nonlinearity	96
1.19	A Simple Line Shape Model for GaAs Multiple Quantum Wells	96
1.20	Coherent Fusion Theory	98
<b>Chapter 2</b>	<b>Novel Processes and Materials for Infrared Nonlinear Optics</b>	<b>103</b>
	<i>Professor Peter A. Wolff, Dr. Sunny Y. Auyang</i>	
2.1	Project Description	103

Table of Contents

<b>Section 3</b>	<b>Surfaces and Interfaces</b>	<b>107</b>
<b>Chapter 1</b>	<b>Statistical Mechanics of Surface Systems and Quantum-Correlated Systems</b>	<b>109</b>
	<i>Professor A. Nihat Berker</i>	
● 1.1	Introduction	109
● 1.2	Finite-Temperature Phase Diagram of Vicinal Si(100) Surfaces	109
● 1.3	Absence of First-Order Phase Transitions in Physical Surface Systems	109
● 1.4	New Orderings in Systems with Competing Interactions	110
<b>Chapter 2</b>	<b>X-Ray Diffuse Scattering</b>	<b>111</b>
	<i>Professor Robert J. Birgeneau</i>	
● 2.1	Introduction	111
● 2.2	Metal Surface Studies	111
● 2.3	Semiconductor Surface Studies	112
● 2.4	Rare Gases in Graphite	113
<b>Chapter 3</b>	<b>Semiconductor Surface Studies</b>	<b>115</b>
	<i>Professor John D. Joannopoulos</i>	
● 3.1	Introduction	115
● 3.2	Thermal Amplitudes of Surface Atoms	115
● 3.3	Heteroepitaxial Growth	118
<b>Chapter 4</b>	<b>Ultralow Temperature Studies of Nanometer Size Semiconductor Devices</b>	<b>121</b>
	<i>Professor Marc A. Kastner</i>	
● 4.1	Project Description	121
<b>Chapter 5</b>	<b>The Quantum Hall Effect in Narrow MOSFETs</b>	<b>123</b>
	<i>Professor Patrick A. Lee</i>	
● 5.1	Project Description	123
<b>Chapter 6</b>	<b>Epitaxy and Step Structures on Semiconductor Surfaces</b>	<b>125</b>
	<i>Professor Simon G.J. Mochrie</i>	
● 6.1	Project Description	125
<b>PART II</b>	<b>APPLIED PHYSICS</b>	
<b>Section 1</b>	<b>Atomic, Molecular and Optical Physics</b>	<b>129</b>
<b>Chapter 1</b>	<b>Quantum Optics and Photonics</b>	<b>131</b>
	<i>Professor Shaoul Ezekiel</i>	
1.1	Microwave Phase Dependent Optical Absorption	131
1.2	A New Approach to Microwave Excitation of Atomic Beams	132
1.3	Stimulated Brillouin Fiber optic Gyroscope	136

<b>Chapter 2</b>	<b>Basic Atomic Physics</b> .....	<b>139</b>
	<i>Professor Daniel Kleppner, Professor David E. Pritchard</i>	
● 2.1	Experimental Study of Small Ensembles of Atoms in a Microwave Cavity .....	139
2.2	Rydberg Atoms in a Magnetic Field .....	143
2.3	Millimeter-Wave Measurement of the Rydberg Constant .....	146
● 2.4	Precision Mass Spectroscopy of Ions .....	148
2.5	Neutral Atom Trap .....	153
<b>Chapter 3</b>	<b>Small Angle X-Ray and Neutron Scattering - Its Application to Supramolecular Solutions</b> .....	<b>157</b>
	<i>Professor Sow-Hsin Chen</i>	
3.1	Interlayer Diffusion in Langmuir-Blodgett Films .....	157
3.2	Thermodynamics of Protein/Surfactant Complex in Aqueous Solution and Reptation Mechanism for Protein/SDS Polyacrylamide Gel Electrophoresis .....	158
3.3	Phase Separation in a Lipid/Water/Urea Micellar System .....	160
3.4	Ion Distribution and Solubilization in Reverse Micelles .....	160
3.5	Ion Distribution around DNA Molecules .....	160
3.6	Structural Study of Vesicles Formed from a New Bolaamphiphile .....	161
3.7	Photon Correlation Spectroscopy and Its Applications: Dynamic Transition at the Percolation Threshold of a Three-Component Microemulsion .....	163
<b>Section 2</b>	<b>Plasma Physics</b>	<b>165</b>
<b>Chapter 1</b>	<b>Plasma Dynamics</b> .....	<b>167</b>
	<i>Professor George Bekefi, Professor Abraham Bers, Professor Bruno Coppi, Professor Miklos Porkolab, Riccardo Betti, Dr. Paolo Detragiache, Dr. Ronald C. Englade, Dr. Stanley C. Luckhardt, Dr. Stefano Migliuolo, Dr. Abhay K. Ram, Dr. Linda E. Sugiyama</i>	
1.1	Relativistic Electron Beams .....	167
1.2	Plasma Wave Interactions - RF Heating and Current Generation .....	169
1.3	Physics of Thermonuclear Plasmas .....	181
1.4	Investigation of Electron Cyclotron Resonance Plasma Production in the Versator II Tokamak .....	191
<b>Section 3</b>	<b>Electromagnetics</b>	<b>195</b>
<b>Chapter 1</b>	<b>Electromagnetic Wave Theory and Applications</b> .....	<b>197</b>
	<i>Professor Jin Au Kong, Dr. Sami M. Ali, Dr. Robert T. Shin, Dr. Ying-Ching E. Yang</i>	
● 1.1	Electromagnetic Waves in Multilayer Media .....	197
1.2	Remote Sensing of Earth Terrain .....	202
1.3	Remote Sensing of Sea Ice .....	208
1.4	SAR Image Interpretation and Simulation .....	212
1.5	Microwave and Millimeter Wave Integrated Circuits .....	215
1.6	High-Speed Integrated Circuit Interconnects .....	218
1.7	ILS/MLS Frequency Management Assessment .....	220

Table of Contents

**Section 4 Radio Astronomy 223**

**Chapter 1 Radio Astronomy ..... 225**

*Professor Bernard F. Burke, Professor David H. Staelin, Professor Jacqueline N. Hewitt,  
Dr. Philip W. Rosenkranz*

1.1	Galactic and Extragalactic Research .....	225
1.2	Gravitational Lens Search .....	225
1.3	Orbiting VLBI .....	229
1.4	Development of an Undergraduate Laboratory .....	230
1.5	Radio Interferometry of Nearby dMe Stars .....	231
1.6	Gravitational Lenses as Astrophysical Laboratories .....	231
1.7	Tiros-N Satellite Microwave Sounder .....	231
1.8	Long-Baseline Astrometric Interferometer .....	232
1.9	Nonthermal Radio Emission from the Jovian Planets .....	232
1.10	High-Resolution Passive Microwave Imaging of Atmospheric Structure .....	233
1.11	Characterization of Dolphin Whistles .....	234
1.12	Rapid Precision Net-Form Manufacturing .....	234

**PART III SYSTEMS AND SIGNALS**

**Section 1 Digital Signal Processing 239**

**Chapter 1 Signal Processing Research Program ..... 241**

*Professor Alan V. Oppenheim*

1.1	Introduction .....	241
1.2	Algorithmic Fault Tolerance in Digital Signal Processing .....	241
1.3	Active Noise Cancellation Using the EM Algorithm .....	243
1.4	Iterative Maximum Likelihood Time Delay and Doppler Estimation Using Stationary Signals .....	244
1.5	Estimation and Correction of Geometric Distortions in Side-Scan Sonar Images .....	245
1.6	An Algorithm Design Environment for Signal Processing .....	245
1.7	Compiling Signal Processing Algorithms into Architectures .....	246
1.8	Vector Quantization with Adaptive Structured Codebooks .....	247
1.9	The Application of Complex Approximation Algorithms to the Design of Robust Range-Dependent Beamformers .....	249
1.10	Analysis and Applications of an Adaptively Trained Recurrent Neural Network .....	249
1.11	A Code-Division, Multiple Beam Sonar Imaging System .....	250
1.12	Back-projection with Fourier Series Expansion and FFT .....	250
1.13	Iterative Algorithms for Parameter Estimation from Incomplete Data and Their Applications to Signal Processing .....	251
1.14	Equalization (Identification) of Non-Minimum Phase Systems .....	251
1.15	Signal Processing with 1/f Processes Using Wavelets .....	252

**Chapter 2 Speech Processing Research Program ..... 253**

*Professor Jae S. Lim*

2.1	Introduction .....	253
2.2	Development of a 1.5 Kbps Speech Vocoder .....	253
2.3	A New Method for Representing Speech Spectrograms .....	254
2.4	A Dual Excitation Speech Model .....	254
2.5	Image Texture Modeling .....	255
2.6	Speech Enhancement Techniques for the Dual Excitation Vocoder Model .....	255

<b>Chapter 3</b>	<b>Advanced Television Research Program</b>	<b>257</b>
	<i>Professor Jae S. Lim, Professor William F. Schreiber</i>	
3.1	Advanced Television Research Program	257
3.2	Adaptive Amplitude Modulation for Transform Coefficients	258
3.3	Transform Coding for High Definition Television	259
3.4	Filter Design for Multirate Filter Banks	260
3.5	Adaptive Spatiotemporal Filtering	260
3.6	Signal Processing for Advanced Television Systems	261
3.7	Adaptive Frequency Modulation for Satellite Television Systems	261
3.8	Subband Coding for Channel-Compatible Transmission of High-Definition Television	262
3.9	Channel Equalization and Interference Reduction Using Adaptive Amplitude Modulation and Scrambling	263
3.10	A Novel QMF Design Algorithm	264
<b>Chapter 4</b>	<b>Computer-Aided Fabrication System Structure</b>	<b>265</b>
	<i>Professor Donald E. Troxel</i>	
4.1	Introduction	265
4.2	Computer-Aided Fabrication Environment	265
<b>Chapter 5</b>	<b>Optical Propagation and Communication</b>	<b>267</b>
	<i>Professor Jeffrey H. Shapiro, Dr. Robert H. Rediker, Dr. Ngai C. Wong</i>	
5.1	Introduction	267
5.2	Squeezed States of Light	267
5.3	Laser Radar System Theory	269
5.4	Fiber-Coupled External-Cavity Semiconductor High Power Laser	271
5.5	Analog Processing of Optical Wavefronts Using Integrated Guided-Wave Optics	272
<b>Chapter 6</b>	<b>Custom Integrated Circuits</b>	<b>275</b>
	<i>Professor Jonathan Allen, Professor John L. Wyatt, Jr., Professor Srinivas Devadas, Professor Jacob White</i>	
● 6.1	Custom Integrated Circuits	275
6.2	The Vision Chip Project	279
6.3	Techniques for Logic Synthesis, Testing and Design-for-Testability	283
6.4	Mixed Circuit/Device Simulation	288
6.5	Circuit Simulation Algorithms for Specialized Applications	289
6.6	Numerical Simulation of Short Channel MOS Devices	290
6.7	Efficient Capacitance Extraction Algorithms	291
6.8	Parallel Numerical Algorithms	292
6.9	Integrated Circuit Reliability	292
<b>Chapter 7</b>	<b>Neurophysiology and Neural Computation</b>	<b>295</b>
	<i>Professor Jerome Y. Lettvin</i>	
7.1	Abstracts of Doctoral Dissertations	295
7.2	Abstract of Masters Thesis	296

Table of Contents

**PART IV LANGUAGE, SPEECH AND HEARING**

<b>Section 1</b>	<b>Speech Communication</b>	<b>299</b>
<b>Chapter 1</b>	<b>Speech Communication</b> .....	<b>301</b>
	<i>Professor Kenneth N. Stevens, Dr. Joseph S. Perkell, Dr. Stefanie Shattuck-Hufnagel</i>	
1.1	Introduction .....	302
1.2	Studies of the Acoustics, Production and Perception of Speech Sounds .....	302
1.3	Studies and Models of the Perception and Production of Syllables, Words, and Sentences .....	306
1.4	Basic Speech Physiology .....	309
1.5	Speech Production of Cochlear Implant Patients .....	310
1.6	Phonatory Function Associated with Misuse of the Vocal Mechanism .....	310
1.7	Computer Facilities .....	311
<b>Section 2</b>	<b>Sensory Communication</b>	<b>313</b>
<b>Chapter 1</b>	<b>Auditory Psychophysics and Aids for the Deaf</b> .....	<b>315</b>
	<i>Professor Louis D. Braida, Nathaniel I. Durlach, Dr. William M. Rabinowitz, Dr. Charlotte M. Reed, Dr. Patrick M. Zurek</i>	
1.1	Introduction .....	315
1.2	Binaural Hearing .....	315
1.3	Hearing Aid Research .....	315
1.4	Tactile Communication of Speech .....	315
1.5	Multimicrophone Hearing Aids .....	315
1.6	Cochlear Prostheses .....	316
1.7	Hand Function .....	316
<b>Section 3</b>	<b>Auditory Physiology</b>	<b>319</b>
<b>Chapter 1</b>	<b>Signal Transmission in the Auditory System</b> .....	<b>321</b>
	<i>Professor Lawrence S. Frishkopf, Professor Nelson Y.S. Kiang, Professor William T. Peake, Professor William M. Siebert, Professor Thomas F. Weiss, Dr. Bertrand Delgutte, Dr. Donald K. Eddington, Dr. John J. Guinan, Dr. Robert A. Levine</i>	
1.1	Introduction .....	321
1.2	Signal Transmission in the External- and Middle-Ear .....	321
1.3	Cochlear Mechanisms .....	324
1.4	Regeneration of Primary-Auditory Neurons In Vitro .....	325
1.5	Stimulus Coding in the Auditory Nerve .....	326
1.6	Middle-Ear Muscle Reflex .....	327
1.7	Cochlear Efferent System .....	328
1.8	The Generators of the Brainstem Auditory Evoked Potential .....	329
1.9	Cochlear Implants .....	330
1.10	Anatomical Basis for the Relationships between Binaural Hearing and Brainstem Auditory Evoked Potentials in Humans .....	331



<b>Section 4</b>	<b>Linguistics</b>	<b>335</b>
<b>Chapter 1</b>	<b>Linguistics</b> .....	<b>337</b>
	<i>Professor Noam Chomsky, Professor Morris Halle</i>	
1.1	Introduction .....	337
1.2	Abstracts of Doctoral Dissertations .....	337
<b>APPENDICES</b>		
<b>Appendix A</b>	<b>RLE Publications and Meeting Papers</b> .....	<b>343</b>
A.1	Meeting Papers Presented .....	343
A.2	Published Meeting Papers .....	350
A.3	Meeting Papers Accepted For Publication .....	354
A.4	Published Journal Articles .....	355
A.5	Journal Articles Accepted for Publication .....	363
A.6	Journal Articles Submitted for Publication .....	366
A.7	Books/Chapters in Books .....	367
A.8	RLE Publications .....	368
A.9	Theses .....	369
A.10	Miscellaneous Publications .....	371
<b>Appendix B</b>	<b>Current RLE Personnel</b> .....	<b>373</b>
<b>Appendix C</b>	<b>RLE Research Support Index</b> .....	<b>379</b>
<b>PROJECT STAFF AND SUBJECT INDEX</b>	.....	<b>383</b>

