

Contents

1. Introduction	
By F. J. Duarte	1
1.1 Objectives	3
1.2 Brief Survey of Contents	3
1.3 Perspective	5
References	6
2. Dispersive Dye Lasers	
By F. J. Duarte (With 10 Figures)	7
2.1 Resonator Outlines	7
2.1.1 Class I: Intrinsic Narrow Beam Waist Resonators	8
2.1.2 Class II: Resonators Utilizing Intracavity Beam Expansion	9
2.2 Theory	12
2.2.1 Ray Transfer Matrices	12
2.2.2 Intracavity Dispersion	18
2.2.3 Intracavity Transmission Efficiency	19
2.2.4 Fabry-Pérot Etalons	19
2.3 Architecture and Mechanics	20
2.3.1 Physical Requirements on Architecture	21
2.3.2 Specifications for Optical Components	23
2.3.3 Thermal and Dye Flow Control	24
2.3.4 ASE Reduction	25
2.3.5 Wavelength Tuning	26
2.4 Multiple-Prism Beam Expander Configurations: Examples	27
2.5 Single-Longitudinal-Mode HMPGI Dye Laser Oscillator: Example	33
2.6 Generation of Extremely Elongated Gaussian Beams for Interferometry	35
2.7 Summary	38
Appendix	38
A. Multiple-Prism Dispersion and Pulse Compression in Femtosecond Dye Lasers: Numerical Results	38
References	41

3. Pulsed Dye Laser Gain Analysis and Amplifier Design

By C. Jensen (With 22 Figures)	45
3.1 Time Dependent Dynamics of a Laser Dye	48
3.1.1 Short Pulse Pumping	51
3.1.2 Long Pulse Pumping	52
3.1.3 Excimer Laser Pumping	52
3.2 Steady State Approximate Theory	55
3.3 Experimental Series for Analyzing a Laser Dye	58
3.3.1 Fluorescence Yield	60
3.3.2 Transmission	62
3.3.3 Gain	69
3.4 The Fit of Data to Differential Equations	71
3.5 Quantum Yield	74
3.6 Amplifier Design	77
3.6.1 Double-Sided Pumped Amplifier	83
3.7 Summary	89
References	89

4. Large-Scale, Excimer-Laser-Pumped Dye Lasers

By C. Tallman and R. Tennant (With 28 Figures)	93
4.1 Basics	93
4.1.1 Design Configuration	93
4.1.2 Dye-Cell Design	94
4.1.3 Flow Requirements	94
4.1.4 Dye Flow Loop	96
4.2 Dye and Solvent Considerations	97
4.2.1 Dye Selection	97
4.2.2 Efficiency	97
4.2.3 Dye Stability	99
4.2.4 Solvent Effects on Dye Stability	101
4.2.5 Solvent Stability	103
4.2.6 Dye Handling	104
4.2.7 Solvent Handling	104
4.2.8 Dye Solubility	105
4.3 Optical Damage	107
4.3.1 Optical Damage Studies	107
4.3.2 Particulates	110
4.3.3 Bubble Formation	110
4.3.4 Solvent Chemistry Particle Generation	112
4.3.5 Other Sources of Particulates	112
4.3.6 Filters	112
4.4 Fluid Issues	113
4.4.1 Flow Dynamics	113
4.4.2 Flow Uniformity	115
4.4.3 Dye-Cell Design Considerations	116
4.4.4 Flow Loop Pumps	118

4.5	Excimer Laser Considerations	120
4.5.1	Excimer Laser Pump	120
4.5.2	Excimer Laser Component Lifetime	121
4.5.3	Electrode Wear	121
4.5.4	Window Lifetime	123
4.5.5	Bearing Lifetime	123
4.5.6	Heat Exchanger Lifetime	123
4.5.7	Gas Lifetime	124
4.5.8	Excimer Laser Gas Contamination Sources	124
4.5.9	Excimer Laser Gas Halogen Depletion	125
4.6	Gas Processors	126
4.6.1	Typical Excimer Laser Gas Lifetime Performance	127
4.6.2	Beam Characteristics	128
	a) Temporal	128
	b) Spatial Intensity Profile	128
	c) Beam Quality	128
4.6.3	Jitter	129
4.6.4	Timing Drift	129
4.6.5	Automatic Timing Control Loop	129
4.7	Dye Laser	130
4.7.1	Specific Design	130
4.7.2	Experimental Results with Cyclohexane Solvent	133
4.7.3	Experimental Results with Dioxane	136
4.7.4	Dye Laser Configuration Using Dioxane Solvent	137
4.7.5	Power Oscillator Configuration	138
4.7.6	Power Oscillator Performance	139
4.7.7	Homogenized Pump Beam Experiments	139
4.7.8	System Considerations	141
	References	141
5.	High-Power Dye Lasers Pumped by Copper Vapor Lasers	
	By C.E. Webb (With 25 Figures)	143
5.1	The Elemental Copper Vapor Laser	144
5.1.1	History of Development	144
5.1.2	Excitation Mechanisms	145
5.1.3	Practical Considerations	147
5.1.4	Repetition Rate Capability	148
5.1.5	Optimum Temperature and Green/Yellow Ratio	150
5.1.6	Power Scaling	151
5.2	Copper Halide Lasers	151
5.3	CVL Beam Quality	153
5.3.1	The Importance of Beam Quality	153
5.3.2	Plane-Plane Cavities	154
5.3.3	The Unstable Cavity	154
5.3.4	Injection Controlled Oscillator	157
5.3.5	CVL Amplifier Properties	157

5.4 CVL Pumped Dye Lasers – Theory	158
5.4.1 Rate Equations, Gain, Saturation Intensity	158
5.4.2 Longitudinal Pumping Geometry	161
5.4.3 Transverse Pumping Geometry	162
5.4.4 Dye Cell Design	164
5.4.5 Pump Beam Polarization Issues	165
5.5 CVL Pumped Dye Lasers – Performance	166
5.5.1 Broadband Dye Laser Oscillators	166
5.5.2 Narrow-Linewidth Dye Laser Oscillators	168
5.5.3 Dye Laser Oscillator-Amplifier Performance	170
5.6 Applications of CVL Pumped Dye Lasers	173
5.6.1 Medical	173
5.6.2 Ultrafast Pulse Amplification	175
5.6.3 Resonant Ionization Mass Spectrometry – RIMS	177
5.6.4 Atomic Vapor Laser Isotope Separation (AVLIS)	180
References	181
 6. Flashlamp-Excited Dye Lasers	
By P.N. Everett (With 8 Figures)	183
6.1 Development of FEDLs	183
6.2 General Design Considerations	186
6.2.1 Where Does the Energy Go?	187
6.3 Flashlamps	188
6.3.1 Simmer, Lamp Efficiency and Life	189
6.3.2 Pulse, Energy, Shape and Length	190
6.3.3 Power Supplies and Modulators	191
6.3.4 Emission Characteristics	192
a) Black Body Model	193
b) Temperature Related to Current Density	195
c) Quantitative Comparisons	195
6.3.5 Unconventional Lamps	196
a) Ablating Silica Lamps	196
b) Vortex Stabilized Lamp	197
c) Open Discharge Lamp	198
d) High Pressure Arc Lamp	198
e) Pinched Discharge Lamp	198
f) Argon Bomb Lamp	198
g) Potential Improvements in Efficiency	198
h) How Critical is the Fill?	199
6.3.6 Lamp Degradation	199
a) Expected Lamp Life	199
b) Recent Experimental Data	201
c) Discussion of Lamp Life	201
d) Lamp Cooling	202
6.4 Coupling the Flashlamp to the Dye	202
6.4.1 UV Filtering	204

6.5	The Dye	204
6.5.1	Dye Spectroscopy	205
6.5.2	Significant Transitions	206
6.5.3	Cross Sections and Wavelength Dependence	206
6.5.4	Labeling	207
6.5.5	Fluorescent and Lasing Quantum Efficiencies	207
6.5.6	Dimers	208
6.6	Rate Equation Analysis	208
6.6.1	Gain and Saturation – Basic Transitions	209
6.6.2	Lasing Quantum Efficiency – Basic Transitions	210
6.6.3	Gain and Saturation, Including Other Losses	210
6.6.4	Pumping, Including Other Losses	211
6.6.5	Lasing Quantum Efficiency with Other Losses	212
6.6.6	Effect of Dye Concentration	212
6.6.7	Generalization to Spectrally Broad Pump	213
6.6.8	Discussion	213
6.6.9	Example: Analysis for Rhodamine 6G	214
	a) Population Distribution and Shifting of Wavelength	216
	b) Dye Degradation	217
	c) Triplet Quenching	217
6.6.10	Shape and Size of Dye Cell and Laser Head	218
6.7	Efficiency Improvement by Spectral Conversion	218
6.8	Solvent, Flow Systems, and Solvent Recycling	220
6.8.1	Flow Through Laser Head	220
6.8.2	Regeneration of Dye Solution	220
6.8.3	Optical Quality of Medium and Other Factors	221
6.9	Resonators and Propagation	222
6.9.1	Concepts	223
6.9.2	Unstable Resonators	224
	a) Geometric “Self-Consistent” Analysis	224
	b) Example	225
	c) Geometric “Virtual Source” Analysis	226
	d) Sensitivity to Errors in Resonator and Lensing in Medium	226
	e) Alignment of Unstable Resonators	227
6.9.3	Gaussian Analysis of Unstable Resonators	228
	a) Higher-Order Gaussian Analysis	229
6.9.4	Waveguide Resonators	230
6.9.5	Propagation	230
	a) Diffraction Close to an Aperture	232
6.9.6	Optical Elements	233
6.9.7	Isolation	233
6.10	Pulse Length	234
6.11	Spectral Control	235
6.11.1	Injection Locking	236

6.11.2 Mode Control	238
6.11.3 Amplified Spontaneous Emission	238
6.11.4 Frequency Conversion	238
Appendix	239
A. Correlation of the Dye Models of Chaps. 3 and 6	239
References	240
Subject Index	247