

TABLE OF CONTENTS

Chapter 1:	Introduction.....	1
1.1	Semiconductor Lithography.....	1
Chapter 2:	Deep-UV (DUV) Resist Technology.....	3
2.1	Imaging.....	3
2.1.1	Contributions of Physics and Chemistry.....	4
2.1.1.1	Interaction of Light with Matter.....	4
2.1.1.2	Resolution.....	5
2.1.1.3	Thin Film Imaging/Standing Wave Effects.....	6
2.2	DUV Resists.....	8
Chapter 3:	The CARL® Process.....	13
3.1	Top Surface Imaging (TSI).....	13
3.2	The CARL® Process.....	14
3.2.1	Imaging.....	14
3.2.2	The Bottom Coating.....	17
3.2.3	The DUV-CARL® Photoresist.....	18
3.2.3.1	Polymer Backbone.....	18
3.2.3.2	Photoacid Generators (PAGs).....	19
Chapter 4:	Novel Acid Diffusion Analysis in Advanced Chemically Amplified DUV Resists Using Photometric Methods.....	21
4.1	Introduction.....	21
4.2	Experimental.....	22
4.2.1	Materials and Apparatus.....	22
4.2.1.1	Materials.....	22
4.2.1.2	Apparatus.....	22
4.2.2	Method Specific Techniques.....	23
4.2.2.1	Photoacid Generation Efficiencies.....	23
4.2.2.2	Acid Evaporation ("Sandwich-Test").....	23
4.2.2.3	Diffusion/Molecular Reaction Dynamics.....	24
4.3	Results and Discussion.....	24
4.3.1	Photoacid Generation Efficiencies.....	24
4.3.1.1	Acid Generation in Thin Polymer Films.....	24
4.3.1.2	Photoacid Generation Efficiencies.....	26
4.3.2	Acid Evaporation.....	27
4.3.3	Diffusion/Molecular Reaction Dynamics.....	29
4.3.3.1	Pseudo-Arrhenius Behavior.....	29
4.3.3.1.1	Sensitivity Analysis.....	29
4.3.3.1.2	Photometric Method.....	30
4.3.3.2	Photoresist Bake Effects.....	30
4.3.3.2.1	Pre Bake (PB).....	30
4.3.3.2.2	Post-Exposure Bake (PEB).....	32
4.3.3.3	Diffusion/Modeling the Bakes.....	33
4.3.3.3.1	Kinetic Model.....	33
4.3.3.3.2	Transport Properties.....	37
4.3.3.3.3	Estimations for Pattern Simulation.....	40
4.4	Conclusions.....	43

Chapter 5:	Negative-Tone Resist for Phase-Shifting Mask Technology.....	45
5.1	Introduction.....	45
5.1.1	DUV Lithography with Phase-Shifting Masks (PSMs).....	45
5.1.2	“Blending Concept”.....	46
5.2	Experimental.....	48
5.2.1	Materials and Apparatus.....	48
5.2.1.1	Materials.....	48
5.2.1.1.1	Resist Matrix.....	48
5.2.1.1.2	Photobase Generators (PBGs).....	48
5.2.1.1.3	Thermoacid Generators (TAGs).....	50
5.2.1.2	Apparatus.....	50
5.2.2	Method Specific Techniques.....	50
5.2.2.1	Photobase/Thermoacid Generation Efficiencies.....	50
5.2.2.2	Base/Acid Evaporation (“Sandwich-Test”).....	51
5.2.2.3	Dissolution Rates (DR).....	51
5.2.2.4	Photo-Patterning and Sensitivity Determinations.....	51
5.3	Results and Discussion.....	51
5.3.1	Photobase/Thermoacid Generation Efficiencies.....	51
5.3.2	Base/Acid Evaporation.....	57
5.3.3	Deprotection Chemistry and Diffusion.....	58
5.3.3.1	(Positive-tone) DUV-CARL®.....	58
5.3.3.2	Dissolution Rate.....	59
5.3.3.3	Negative-tone Blend.....	61
5.3.3.3.1	Sensitivity Analysis.....	63
5.3.3.3.2	Lithographic Results.....	64
5.4	Conclusions.....	65
Chapter 6:	Summary, Comments, and Perspective.....	66
6.1	Summary.....	67
6.2	Comments.....	67
6.3	A Final Perspective/Limits of Optical Lithography.....	67