

Contents

INTRODUCTION	1
1 Historical background, research aim, and achieved research objectives	3
1.1 Historical background	3
1.2 Research aim	6
1.3 Achieved research objectives	7
FUNDAMENTALS, MATERIALS, AND METHODS	9
2 Light amplification by stimulated emission of radiation	11
2.1 Laser operation	11
2.2 Continuous wave laser temperature distribution	14
3 Peptide synthesis	17
3.1 Amino acids and peptide bond formation	17
3.2 Solid-phase peptide synthesis	19
3.3 Combinatorial laser-induced forward transfer	20
4 Numerical modeling of fluid flow	23
4.1 Laws of conservation	23
4.2 Numerical discretization methods	25
4.3 OpenFOAM	27
4.4 OpenFOAM solver <i>compressibleInterFoam</i>	28
5 Detection methods	31
5.1 Fluorescence imaging	31
5.2 High-speed imaging	32
5.3 Vertical scanning interferometry	34
5.4 Image analysis	35
6 Experimental materials and methods	39
6.1 Clarifying statement	39
6.2 Acceptor slide etching procedure	40
6.3 Donor slide preparation	40
6.4 Hydrophilization of a microscope glass slide	41
6.5 Hydrophobization of a microscope glass slide	41
6.6 Acceptor slide preparation and AA coupling	41
6.7 Direct labeling of amino groups	41

6.8	Indirect labeling of amino groups with biotin	42
6.9	Peptide array synthesis – acceptor modification	42
6.10	Peptide array synthesis – coupling reaction	43
6.11	Peptide array synthesis – staining	43
RESULTS AND DISCUSSION		45
7	Investigation of the laser transfer mechanisms within the cLIFT process	47
7.1	Clarifying statement	47
7.2	Deposition influences and mechanistic proposals	48
7.3	Imaging of the laser transfer mechanism	49
7.4	Characterization of the material deposition	52
7.5	Modeling of the polyimide irradiation	61
7.6	Model validation and numerical results	62
8	High-precision and high-throughput laser-based macromolecular synthesizer	67
8.1	Clarifying statement	67
8.2	Problem definition and synthesizer concept	68
8.3	Laser transfer system	69
8.4	Transportation and positioning system	71
8.5	Control system and interfaces	76
8.6	Randomized transfer algorithm	78
9	cLIFT peptide synthesis analysis and optimization	81
9.1	Clarifying statement	81
9.2	State-of-the-art and optimization aim	82
9.3	Amino acid coupling and evaluation methods	82
9.4	Donor slide optimization	85
9.5	Intermediate control peptide array synthesis	88
9.6	Minimal Flag epitope sequence	91
9.7	20 layer validation peptide array synthesis	92
SUMMARY, CONCLUSION, AND OUTLOOK		99
10	Summary, conclusion, and outlook	101
10.1	Summary and conclusion	101
10.2	Outlook	105
APPENDIX		107
A	Investigation of laser transfer mechanism within the cLIFT process	109
A.1	Clarifying statement	109
A.2	Laser spot diameter	110
A.3	Characterization of the material deposition	111

B	High-precision and high-throughput laser-based macromolecular synthesizer	115
B.1	Clarifying statement	115
B.2	Telegram writer	116
B.3	Stacked color gradients	118
C	cLIFT peptide synthesis analysis and optimization	119
C.1	Clarifying statement	119
C.2	Donor slide optimization	120
C.3	Intermediate control peptide array synthesis	129
C.4	20 layer validation peptide array synthesis	137