

Contents

1	Introduction	1
2	Theoretical background	5
2.1	Key concepts of electromagnetism	5
2.1.1	Maxwell's and wave equations	5
2.1.2	Optics of metals	9
2.1.3	Optical scattering of small particles	12
2.1.4	Antenna basics	15
2.2	Full-field modeling	17
2.2.1	Finite-difference time-domain method	17
2.2.2	Finite element method	21
3	Experimental methods	25
3.1	Focused beams of charged particles	25
3.1.1	Scanning electron microscope	25
3.1.2	Electron-sample interaction	26
3.1.3	Focused ion beam microscope	27
3.1.4	Ion-sample interaction and milling	28
3.1.5	Dual beam microscope	29
3.2	Fabrication with focused electron beams	29
3.2.1	Focused electron beam induced deposition	30
3.2.2	Parameters, affecting the growth	31
3.2.3	Purification strategy	33
3.2.4	Patterning with stream files	35
3.3	Optical characterization of helical plasmonic antennas	36
3.4	Chemical vapor deposition of thin metal films	38
3.4.1	Area-selective chemical vapor deposition	40
3.5	Complementary methods	42
3.5.1	Sample preparation for electron beam writing	42
3.5.2	Sample preparation and deposition parameters for area-selective chemical vapor deposition	42

3.5.3	Additional tools	43
4	Double helical plasmonic antennas	45
4.1	Introduction	45
4.2	Theoretical considerations	46
4.2.1	Single plasmonic helix	47
4.2.2	Mode hybridization and extension of analytical design tool	48
4.2.3	Quantification of the chiroptical interaction	50
4.3	Full-field simulations	51
4.3.1	Extinction of a free-standing double helix	51
4.3.2	Far-field radiation pattern of a free-standing double helix	55
4.3.3	Numerical representation of the transmission measurements through a double helix on a substrate	57
4.4	Fabrication with the electron beam and material analysis	59
4.5	Optical characterization	62
4.6	Conclusion and outlook	63
5	Plasmonic polarization converter	65
5.1	Introduction	65
5.1.1	Two-wire transmission line	65
5.2	Coupling between the double helix and the transmission line	67
5.2.1	Optimization parameters	68
5.2.2	Particle swarm optimization	70
5.2.3	Directivity pattern and polarization state	71
5.3	Fabrication of adiabatic transition region	73
5.3.1	Archimedean spiral pattern	73
5.3.2	Direct electron beam writing	75
5.4	Conclusion and outlook	77
6	Area-selective chemical vapor deposition of gold by electron beam seeding	79
6.1	Introduction	79
6.2	Area-selective chemical vapor deposition of gold	80
6.2.1	Electron beam seeding	80
6.2.2	Experimental array for seeding	81
6.2.3	Experimental matrix for autocatalytic gold growth without electron irradiation	83
6.2.4	Characterization of the obtained films	85
6.2.5	Complementary studies	90

6.3	Control experiments	92
6.3.1	Electron beam induced surface activation	93
6.3.2	Use of gold-free precursors for seeding	94
6.3.3	No precursor flow during autocatalytic growth	96
6.4	Autocatalytic growth of gold enhanced by electron beam irradiation . . .	96
6.5	Temperature evolution in direct electron beam writing	98
6.5.1	Direct electron beam deposition of nanopillars on a substrate at elevated temperatures	98
6.5.2	Temperature distribution in nanopillars induced by the electron beam	101
6.5.3	Thermal conductivity of material, deposited with the electron beam	103
6.5.4	Material analysis	104
6.6	Reproducibility in different scanning electron microscope	105
6.7	Conclusion and outlook	106
7	Conclusion and perspectives	109
A	Appendix	111
	Bibliography	115