

Contents

1	Introduction	1
1.1	Optical Technology	1
1.2	Integrated optics	1
1.3	Silicon Integrated optics	2
1.4	Objective	3
1.5	Methodology	3
1.5.1	Design	3
1.5.2	Fabrication	4
1.5.3	Testing	4
1.6	Outline	5
2	Building blocks	8
2.1	Waveguides	8
2.2	Bends	9
2.3	Fiber to chip coupling	10
2.4	Mach Zehnder interferometer (MZI)	11
2.5	Ring resonators	11
3	Nonlinear effects	17
3.1	Kerr effect	19
3.2	Two photon absorption (TPA)	20
3.3	Free carrier effects	20
4	Paper: Ultrafast nonlinear dynamics in silicon waveguides	26
4.1	Introduction	27
4.2	Fabrication	27
4.3	Experiments	28
4.3.1	Heterodyne characterization	28
4.3.2	All-optical switching	29
4.4	Results	29
4.4.1	Heterodyne experiment	29
4.4.2	Switching experiment	31
4.5	Conclusion	31
5	Paper: Ultrafast all-optical logic gates with Si-nanocrystal slot	34
5.1	Introduction	35
5.2	Fabrication	35
5.3	Characterization	36

5.4	Conclusions	37
6	Paper: Low TPA and free-carrier effects in Si-nanocrystal slot	40
6.1	Introduction	41
6.2	Fabrication	42
6.3	Nonlinear loss measurements: $\text{Im}(\gamma)$	42
6.4	Time-resolved measurements	44
6.5	Time-resolved simulations	45
6.6	Results and conclusion	47
7	Paper: High nonlinear figure-of-merit amorphous silicon	51
7.1	Introduction	52
7.2	Fabrication	53
7.3	Four-wave-mixing: $\text{Re}\{\gamma\}$	54
7.4	Nonlinear loss measurements: $\text{Im}\{\gamma\}$	55
7.5	Time-resolved measurements and simulations	56
7.6	Results	58
7.7	Conclusions	60
8	Conclusions and future lines	63
A	Experimental measurement techniques	67
A.1	All optical switching	67
A.2	Phase-sensitive nonlinear time resolved measurements	68
A.3	Four wave mixing	69
A.4	TPA estimation from pulsed transmission	70
A.5	Phase characterization	73
A.6	Optical vector analyzer	75
B	Paper: Characterizing and modeling backscattering in Si rings	78
B.1	Introduction	79
B.2	Experiment	79
B.3	Theory	80
B.4	Results	83
B.5	Conclusion	84
C	Paper: Optical phase of photonic integrated devices	88
C.1	Introduction	89
C.2	Experimental setup	90
C.3	Results	91
	C.3.1 Ring resonators parameter extraction	91
	C.3.2 Group index in slow light corrugated waveguides	94
C.4	Conclusion	95
D	Simulation algorithms	100
D.1	Modes in a waveguide	100
D.2	Wave propagators	101