

Contents

Preface	i
Abstract	iii
List of Publications and Patents	v
Table of Contents	xi
1 Introduction	1
1.1 Motivation and research context	1
1.2 Silicon Photonics	4
1.2.1 The fiber-to-chip coupling problem	6
1.3 Objectives and organization of this work	8
2 Background	11
2.1 Photonic Waveguides	11
2.1.1 SOI nanophotonic waveguides	11
2.1.1.1 Polarization: polarization transparency	14
2.1.2 SOI slot waveguides	16
2.1.3 Coupling to optical fiber	20
2.2 Efficient coupling to fiber in SOI waveguides	25
2.2.1 Vertical coupling	26
2.2.2 Lateral coupling	27
2.2.3 Grating coupler vs Inverted taper	28
2.2.4 2D-gratings for transparency to polarization	32
2.3 Summary and conclusions	34

CONTENTS

3 Grating-based fiber-to-chip coupling	37
3.1 Diffraction gratings	37
3.2 Grating couplers theory	39
3.3 SOI grating coupler engineering	44
3.3.1 Modelling	44
3.3.2 Design and simulations	48
3.3.3 Fabrication and experimental results	52
3.3.3.1 Multiport grating coupler SOI chips experiments	58
3.4 Horizontal slot waveguide grating couplers	68
3.4.1 Design	69
3.4.2 Fabrication and experimental results	75
3.5 Summary and conclusions	77
4 Inverted taper-based fiber-to-chip coupling	83
4.1 Introduction	83
4.2 Inverted taper approach for V-groove integration	86
4.2.1 Design	88
4.2.1.1 SiO_2 waveguide design and optical fiber choice .	89
4.2.1.2 Inverted taper design	91
4.2.2 Realization	96
4.2.2.1 V-Groove design	97
4.2.2.2 Fabrication and experimental results	99
4.3 Inverted taper structures for horizontal slot waveguides	106
4.3.1 Design	108
4.3.1.1 Inverted taper tip width optimization	109
4.3.1.2 Inverted taper length optimization	110
4.4 Summary and conclusions	113
5 Generic packaging solutions for SOI chips	117
5.1 Silicon Photonics Packaging	117
5.1.1 Fiber Pigtailing	118
5.2 Packaging of multiport silicon PICs with vertical coupling to fiber	121
5.3 Packaging solution for grating coupler SOI devices	123
5.3.1 Description of the packaging solution	125

CONTENTS

5.3.2	Detailed description	126
5.3.2.1	Extensions for different shape FLEX designs . . .	129
5.3.2.2	Mirroring and arrays	132
5.3.3	Demonstrator prototyping	135
5.4	Summary and conclusions	139
6	Conclusions and perspectives	143
6.1	Conclusions	143
6.2	Perspectives	146
6.3	Summary of achieved results	150
Bibliography		151
List of Figures		167
List of Tables		177