

Index

1.	Introduction.....	6
1.1	Context of research	7
1.2	Biosensors	10
1.2.1	Immunosensors	12
1.2.2	Immunoassay formats	13
1.2.3	Steps for the development of immunosensors	15
1.3	Sensing technologies for biochemical sensors.....	19
1.4	Why Acoustic?.....	21
1.5	Acoustic Wave devices	22
1.5.1	Quartz Crystal Microbalance (QCM).....	25
1.5.2	Thin film bulk acoustic resonators (FBAR).....	28
1.5.3	Rayleigh wave (SAW)	30
1.5.4	Shear-Horizontal Surface Acoustic Wave (SH-SAW).....	32
1.5.5	Surface Transverse Wave (STW).....	33
1.5.6	Love wave (LW)	35
1.5.7	Shear-Horizontal Acoustic Plate Mode (SH-APM).....	37
1.5.8	Layer-Guided Acoustic Plate Mode (LG-APM).....	38
1.5.9	Flexural Plate Wave (FPW)	39
1.5.10	Performance comparison.....	41
1.6	LW biosensors state-of-the-art.....	46
1.7	Trends and challenges of LW biosensors	49
2.	Thesis objectives	52
3.	Contribution 1: LW sensors fundamentals. Optimization of the design specifications.....	55

3.1	Introduction.....	55
3.2	Basic structure.....	56
3.2.1	Piezoelectric substrate.....	58
3.2.2	Interdigital transducers (IDTs).....	60
3.2.3	Guiding layer	63
3.2.4	Sensing area	65
3.3	Measurement techniques.....	66
3.4	Modeling methods	70
3.4.1	Dispersion equation.....	70
3.4.2	Transmission line model	73
3.4.3	3D FEM simulations	88
3.4.4	Sensitivity and Limit of Detection.....	93
3.5	Studies for defining other design specifications	97
3.5.1	Temperature effect: Selection of the substrate material.....	97
3.5.2	Optimum guiding layer material and thickness for maximum sensitivity	100
3.5.3	Reflectors for enhancing the device response	104
3.5.4	Packaging and flow cells.....	106
3.6	Chapter conclusion.....	109
4.	Contribution 2: Fabrication and characterization of the final LW sensor	113
4.1	Introduction.....	113
4.2	Structure and dimensions of the sensors	114
4.3	Fabrication of the sensors	117
4.3.1	IDTs patterning	117
4.3.2	Silicon dioxide guiding layer PECVD deposition	118
4.3.3	Opening of the contacts.....	119
4.3.4	Gold sensing layer deposition.....	119

4.4	Characteristics of the fabricated sensors.....	120
4.4.1	Atomic Force Microscopy (AFM) images.....	121
4.4.2	Frequency response of the final sensors.....	123
4.4.3	Theoretical mass sensitivity.....	124
4.5	Chapter conclusion.....	127
5.	Contribution 3: LW microsystem for in liquid measurements.....	129
5.1	Design and fabrication of a flow cell for the LW sensor.....	130
5.2	Electronic characterization system.....	138
5.2.1	Electronic characterization system for QCM resonators....	140
5.2.2	Electronic characterization system for LW sensors.....	146
5.3	Proposed characterization system vs. a reference instrument....	151
5.4	Chapter conclusion.....	154
6.	Experimental section.....	155
6.1	Introduction.....	155
6.2	Experiment 1: Glycerol-water solutions' measurements.....	156
6.2.1	Materials and Methods.....	156
6.2.2	Results and discussion.....	160
6.3	Experiment 2: Carbaryl immunosensor.....	163
6.3.1	Materials and methods.....	164
6.3.2	Results and discussion.....	171
6.4	LW sensors versus HFF-QCMs.....	186
6.5	Chapter conclusions.....	187
7.	Final conclusions.....	189
	Appendix A. Lamé constants.....	193
	Appendix B. Euler angles.....	195
	Appendix C. Crystal cuts and IEEE standard 176 on piezoelectricity.....	197
	Appendix D. Material properties for LW sensors.....	201

Appendix E. Scattering Parameters	209
Appendix F. Finite Element Method formulation.....	213
Appendix G. Thesis codes	221
List of scientific communications.....	225
References.....	227