

Contents

Acknowledgements	v
Abstract	vii
Résumé	ix
1 Introduction	1
1.1 MEMS for frequency generation and frequency control: from market needs to device	1
1.2 State of the Art	5
1.2.1 Piezoelectric contour mode resonators	5
1.2.2 Resonator performance and figures of merit	9
1.2.3 Aluminum nitride technology	13
1.2.4 Lithium niobate technology	19
1.2.5 Aluminum scandium nitride technology	23
1.3 Thesis outline	25
2 Aluminum nitride contour mode resonators	41
2.1 Anchor loss dependence on electrode materials in contour mode resonators . .	42
2.1.1 Manuscript	42
2.1.2 Supplementary material	53
2.2 Release area confinement in Contour Mode Resonators	57
2.2.1 Manuscript	57
2.2.2 Supplementary material	69
2.3 Engineered acoustic mismatch for anchor loss control in contour mode resonators	73
2.3.1 Manuscript	73
2.3.2 Supplementary material	84

3 Aluminum scandium nitride contour mode resonators	86
3.1 $\text{Al}_{0.83}\text{Sc}_{0.17}\text{N}$ contour mode resonators with electromechanical coupling in excess of 4.5%	87
3.1.1 Manuscript	87
3.1.2 Supplementary material	108
4 From device to system: MEMS-based Oscillator	114
4.1 Phase noise measurements of aluminum scandium nitride oscillators	115
4.1.1 Manuscript	115
4.1.2 Supplementary material	124
5 Conclusions and outlook	128
5.1 Conclusions	128
5.2 Outlook	133
6 Appendix: Transverse spurious mode in contour mode resonators	136
6.1 FEM study of transverse spurious modes	136
6.2 LDV technique for acoustic mode identification	143
Glossary	146
Photographic credits	148
Curriculum Vitae	149