

Table of content

Abstract	I
Zusammenfassung	II
Acknowledgement.....	III
Abbreviation list	IV
Parameter list.....	V
1. Introduction and Motivation	1
1.1 Background of smart glass in green buildings.....	1
1.1.1 Introduction to renewable energy	1
1.1.2 Introduction to green buildings and smart glass	3
1.2 Daylight modulating methodologies and applications: the State-of-the-Art.....	5
1.3 Scope of chapters.....	9
2. Fundamentals and Characteristics of Electrostatically Driven MOEMS Microelements.....	12
2.1 Basic concepts, geometries and working principles of MOEMS microelement arrays	12
2.1.1 Basic concepts of MEMS and MOEMS.....	12
2.1.2 Scaling of fundamental forces in MOEMS	13
2.1.3 Typical actuation mechanisms for MOEMS	14
2.1.4 Geometries and working principles of electrostatically driven planarized MOEMS microelement arrays	16
2.1.5 Daylight steering functions enabled by smart glass applying micromirror arrays .	17
2.2 Stress gradient-based curling of different multi-layered MOEMS microelements	19
2.2.1 Theoretical model of the curling of multi-layered microcantilever structures	20
2.2.2 Curling analysis of different multi-layered microelements with residual stresses .	23
2.3 Fundamentals of electrostatic actuation and pull-in for idealized parallel plates.....	30
2.4 Electrostatic actuation and static pull-in of planarized MOEMS microelements.....	33
2.4.1 Electric fields distribution of planarized microelements	33
2.4.2 Electrostatic forces and bending moments on planarized microelements	34
2.4.3 Elastic restoring forces and restoring moments on planarized microelements.....	38
2.4.4 Static pill-in of planarized microelements.....	39
2.5 Vibrations and Eigenfrequencies of MOEMS microelements as second-order systems40	
2.5.1 Free vibrations and eigenfrequencies of a second-order system	41
2.5.2 Forced vibrations and resonance frequencies of a second-order system	42
2.5.3 Free vibrations and eigenfrequencies of thin cantilever plates.....	43
2.6 Step responses and dynamic pull-in behaviour of MOEMS microelements.....	46
2.6.1 Step response of a second-order system.....	46
2.6.2 Dynamic pull-in behaviours of MOEMS microelements.....	47
2.7 Material properties of metallic MOEMS microelement arrays	47

2.7.1 Influences of mechanical, electrical, optical and chemical parameters on characteristics of microelements	48
2.7.2 Stress-strain curve of materials.....	50
2.7.3 Parameters and mass density-Young's modulus plot of metals	51
3. Simulations of Static and Dynamic Characteristics of MOEMS Microelements	53
3.1 Simulations of curling for multi-layered microelements due to initial stress.....	54
3.1.1 Curling of tri-layered microelements	54
3.1.2 Curling of multi-layered microelements with a stress compensating layer.....	56
3.2 Simulations of static pull-in for different microelements.....	57
3.2.1 Simulations of electric fields for different microelements	58
3.2.2 Simulations of static pull-in for different microelements.....	61
3.3 Simulations of dynamic pull-in and actuation times for microelements	67
3.3.1 Simulations of resistances and capacitances for the microelement arrays	68
3.3.2 Simulations of eigenfrequencies and mode shapes for different microelements....	70
3.3.3 Simulations of dynamic pull-in and actuation times for rectangular microcantilevers	73
3.4 Simulations on pull-in voltages and actuation times for different real metals	78
4. Casimir Effects of Paired Curled Microelements	82
4.1 Fundamentals and research of Casimir effects between solid objects.....	82
4.1.1 Casimir effects between objects of different geometries.....	84
4.1.2 Main measurement methods for Casimir forces.....	89
4.1.3 Contribution of critical parameters to Casimir forces	91
4.1.4 Influences of Casimir forces on MEMS/NEMS characteristics.....	93
4.1.5 Applications of Casimir forces in MEMS/NEMS fields	95
4.2 Simulations of elastic forces and Casimir forces of paired curled microelements.....	98
4.2.1 Introduction to paired curled microelements.....	98
4.2.2 Casimir forces and elastic forces on curled paired microelements.....	99
5. Conclusion and Outlook	105
5.1 Conclusion.....	105
5.2 Outlook	107
References	108
Publication list	124
Appendix	125