

# Contents

<b>Foreword</b>	ix
<b>Preface</b>	xiii
<b>Contributors</b>	xvii
<b>1. Techniques in the Development of Micromachine Tool Prototypes and Their Applications in Microfactories</b>	<b>1</b>
<i>E. Kussul, T. Baidyk, L. Ruiz-Huerta, A. Caballero-Ruiz, G. Velasco, and O. Makeyev</i>	
1. Introduction	2
2. The Main Problems of Microfactory Creation	5
3. The General Rules of Scaling Down of Micromechanical Device Parameters	6
4. The Analysis of Micromachine Tool Errors	8
5. The First Prototype of the Micromachine Tool	23
6. The Second Prototype	26
7. The Second Micromachine Tool Prototype Characterization	27
8. Errors Which does not Decrease Automatically	36
9. Possible Applications of Micromachine Tools	51
10. Discussion	55
11. Conclusions	57
12. Acknowledgements	58
References	58
<b>2. Tool-based Micro Machining and Applications in MEMS</b>	<b>63</b>
<i>EZ. Fang, K. Liu, T.R. Kurfess and G.C. Lim</i>	
1. Introduction	63
2. Micro Cutting	64
3. Micro Grinding	99
4. Micro Electro-discharge Machining	103
5. Electrochemical Micro Machining	107
6. Micro Ultrasonic Machining	112
7. Applications in MEMS	115
8. Summary	120
References	120

<b>3. Micro-machined Passive Valves: Fabrication Techniques, Characterisation and their Application</b>	127
<i>Daniel C.S. Bien, Neil S.J. Mitchell, and Harold S. Gamble</i>	
1. Introduction	127
2. Plate Deflection and Fluid Flow Theory	131
3. Silicon Micromachining	138
4. Systems for Microfluidic Device Characterisation	149
5. Valve Structures	153
6. Microvalve Applications	176
7. Summary	180
References	181
<b>4. Rapid Prototyping and Rapid Tooling Techniques for the Manufacturing of Silicon, Polymer, Metal and Ceramic Microdevices</b>	187
<i>T. Hanemann, W. Bauer, R. Knitter, and P. Woias</i>	
1. Introduction	187
2. Rapid Prototyping Established in the Macroworld	188
3. Rapid Prototyping in Microsystems Technology	201
4. Rapid Prototyping of Nanostructures	233
5. Rapid Tooling for Microreplication	237
6. Conclusion	243
References	244
<b>5. Injection Molding Techniques for the Fabrication of MEMS Elements</b>	257
<i>Masayuki Nakao, Chin Yan, Makoto Yoda</i>	
1. Performance Requirement on Reproduction Parts for MEMS	257
2. Concerns When Reproducing MEMS Parts	258
3. Adding Control Factors for Injection Molding of MEMS Parts	259
4. Injection Molding for MEMS Parts with Added Control Factors	261
5. Injection Molding Technology for Future MEMS/NEMS Parts	266
References	266
<b>6. Excimer Laser Micromachined Three-dimensional Microstructures—Techniques and Applications</b>	267
<i>Chris Hayden</i>	
1. Introduction	267
2. Excimer Laser Operation	268
3. An Overview of Laser Ablation	268
4. Incorporating Excimer Lasers into Micromachining Systems	272
5. Three-dimensional Excimer Laser Micromachining	274
6. Applications of Three-dimensional Microstructures	286
7. Conclusion	287
8. Acknowledgements	288
References	288

<b>7. Techniques in Scanning Acoustic Microscopy for Enhanced Failure and Material Analysis of Microsystems</b>	<b>293</b>
<i>J. Janting</i>	
1. Introduction	293
2. Basic C-SAM Theory	294
3. General SAM Sample Requirements	296
4. SAM State of the Art Analysis and Qualification	297
5. General Failure Examples and New Results on MEMS Test Structures	299
References	307
<b>8. Production Scheduling in MEMS Manufacturing</b>	<b>311</b>
<i>Francis E.H. Tay, Wang Lixin, and Loo Hay Lee</i>	
1. Introduction	312
2. Literature Review and Background Knowledge	316
3. Rules for Production Scheduling	332
4. Simulation Experiments	343
5. Simulation Results and Discussions	360
6. Conclusion	374
7. Further Research	376
References	378
Appendix A The MEMS Manufacturing Process	382
Appendix B The MEMS Process and Processing Steps	385
<b>Index</b>	<b>389</b>