

## Table of Contents

1	Introduction	1
2	Fundamentals	4
2.1	Glass Fibres and Glass Fibre Production	4
2.2	Glass Chemistry and Properties with regard to glass fibres	9
2.3	Glass Fibre Bushings	12
2.3.1	Bushing Materials and Properties	14
2.3.2	Bushing Design	23
2.3.3	Bushing Manufacturing	30
2.3.4	Thermal Performance of Bushings	32
2.4	Additive Manufacturing of Platinum Group Metals	37
2.5	Summary and Scope	42
3	Patent Review	43
3.1	Methodology	43
3.2	Findings	46
3.3	Summary and Conclusion	57
4	Research Goal and Approach	59
4.1	Identification of Central Deficits	59
4.2	Research Questions and Scientific Approach	60
4.3	Contribution, Summary and Conclusion	64
5	Glass and Bushing Benchmark	66
6	Technical Feasibility of Additively Manufactured Bushings	68
6.1	Material Properties of Additively Manufactured PtRh10	68
6.1.1	Definition of Target Criteria	68
6.1.2	Testing of Material Properties	69
6.2	Laboratory Scale Bushing Trials	87
6.3	Industrial Scale Bushing Trials	90
6.4	Summary and Conclusion	92

7	Exploitation of Additive Manufacturing Design Freedoms in Bushing Tip Plates	94
7.1	Geometry Optimization	94
7.2	Theoretical Evaluation	98
7.3	Experimental Validation	101
7.4	Bushing Design Concept	104
7.5	Summary and Conclusion	108
8	Economic Feasibility of Additively Manufactured Bushings	110
8.1	Background	110
8.1.1	Pre-Processing Cost Centre	114
8.1.2	Material Cost Centre	114
8.1.3	Additive Manufacturing Cost Centre	121
8.1.4	Post-Processing Cost Centre	125
8.2	Evaluation of the Economic Feasibility	126
8.3	Market Potential	129
8.4	Summary and Conclusion	133
9	Summary	134
10	Recommendations for Future Research	138
11	List of Figures and Tables	142
11.1	Figures	142
11.2	Tables	147
12	Bibliography	148
13	Appendix A: Abbreviations	168
14	Appendix B: Formula	169
15	Kurzfassung	171
16	Abstract	172