

---

# Contents

<b>Agradecimentos</b>	i
<b>Acknowledgements</b>	iii
<b>Danksagung</b>	v
<b>Resumen</b>	vii
<b>Abstract</b>	xi
<b>Resum</b>	xiii
<b>Contents</b>	xvii
<b>List of Figures</b>	xxi
<b>List of Tables</b>	xxvii
<b>Nomenclature</b>	xxix
<b>Chapter 1 Introduction</b>	1
1.1 State of the Art . . . . .	1
1.2 Motivation . . . . .	4
1.3 Justification . . . . .	4
1.4 Objectives . . . . .	5
1.5 Structure of the Thesis . . . . .	6
<b>Chapter 2 Ceramics Technology</b>	7
2.1 Ceramics . . . . .	8
2.1.1 Thermal Conductivity . . . . .	8
2.1.2 Thermal Expansion Coefficient . . . . .	8
2.1.3 Specific Heat . . . . .	10

---

2.1.4	Melting Point . . . . .	12
2.2	Fracture Mechanics of Ceramics . . . . .	14
2.2.1	Elasticity . . . . .	14
2.2.2	Plasticity . . . . .	15
2.2.3	Creep . . . . .	17
2.2.4	Influence of the Porosity on the Mechanical Strength . . . . .	19
2.2.5	Influence of the Grains on the Mechanical Strength . . . . .	22
2.2.6	Fiber Reinforcement . . . . .	24
2.2.7	Brittleness . . . . .	25
2.2.8	Stress Intensity Factor . . . . .	29
<b>Chapter 3 <i>UO<sub>2</sub></i> Fuel Production Process</b>		<b>33</b>
3.1	<i>UO<sub>2</sub></i> Powder Industrial Scale Production Process . . . . .	33
3.1.1	The Reconversion or Conversion Process . . . . .	35
3.1.1.1	Wet Conversion Processes . . . . .	35
3.1.1.2	Dry Conversion Processes . . . . .	35
3.2	Laboratory Scale Pellet Production Process . . . . .	41
3.2.1	Blending . . . . .	43
3.2.2	Pre-compaction . . . . .	43
3.2.3	Granulation . . . . .	43
3.2.4	Pellet Pressing . . . . .	44
3.2.4.1	Powder Pressing . . . . .	46
3.2.4.2	Green Compact Ejection . . . . .	52
3.2.4.3	Experimental Pressing Procedure . . . . .	54
3.2.5	Sintering . . . . .	55
3.2.5.1	Sintering Stages . . . . .	60
3.2.5.2	Experimental Sintering Process . . . . .	66
3.2.6	Grinding . . . . .	70
3.3	<i>UO<sub>2</sub></i> powder Characterization . . . . .	70
3.3.1	Particle size distribution . . . . .	71
3.3.2	Stoichiometry . . . . .	74
3.3.2.1	Fluorite Crystal Structure . . . . .	74
3.3.2.2	O/U Ratio . . . . .	75
3.3.3	Density . . . . .	76
3.3.4	Specific surface area . . . . .	77
3.3.5	Sinterability . . . . .	78
3.3.5.1	Dilatometry . . . . .	79

3.4 Additive Characterization . . . . .	82
3.4.1 Oxidized Urania . . . . .	82
3.4.2 Azodicarbonamid . . . . .	82
3.4.3 Aluminum Distearate . . . . .	82
3.4.4 Keratin . . . . .	83
<b>Chapter 4 Experimental Procedures</b>	<b>89</b>
4.1 Diametral Compression Test . . . . .	91
4.1.1 Test Procedure . . . . .	93
4.1.2 Weibull Statistics . . . . .	94
4.2 Squirrel Cage Experiment . . . . .	96
4.3 Indentation Test . . . . .	99
4.3.1 Hardness . . . . .	99
4.3.2 Toughness . . . . .	100
4.4 Creep Behavior . . . . .	101
<b>Chapter 5 Analysis of the Results</b>	<b>105</b>
5.1 Microstructure Analysis . . . . .	105
5.1.1 Additives . . . . .	106
5.1.2 Green Density . . . . .	113
5.1.3 Sintering dwell time . . . . .	116
5.2 Diametral Compression Test . . . . .	122
5.3 Squirrel Cage Experiment . . . . .	134
5.4 Indentation Test . . . . .	141
5.5 Creep Behavior . . . . .	148
<b>Chapter 6 Conclusions</b>	<b>153</b>
6.1 General conclusions . . . . .	153
6.2 Microstructure analysis . . . . .	153
6.3 Strength Tests . . . . .	155
6.4 Future Developments . . . . .	158
<b>Bibliography</b>	<b>159</b>
<b>Appendix A</b>	<b>169</b>