



Mechanical reliability and oxygen permeation of $\text{Ce}_{0.8}\text{Gd}_{0.2}\text{O}_{2-\delta}$ - FeCo_2O_4 dual phase membranes

Fanlin Zeng

Energie & Umwelt / Energy & Environment
Band / Volume 529
ISBN 978-3-95806-527-7

UNIVERSITY
OF TWENTE.

 JÜLICH
Forschungszentrum

Forschungszentrum Jülich GmbH
Institut für Energie- und Klimaforschung
Werkstoffstruktur und -eigenschaften (IEK-2)

Mechanical reliability and oxygen permeation of $\text{Ce}_{0.8}\text{Gd}_{0.2}\text{O}_{2-\delta}$ - FeCo_2O_4 dual phase membranes

Fanlin Zeng

Schriften des Forschungszentrums Jülich
Reihe Energie & Umwelt / Energy & Environment

Band / Volume 529

ISSN 1866-1793

ISBN 978-3-95806-527-7

Content

SUMMARY

SAMENVATTING

1 Introduction.....	1
1.1 Energy consumption	2
1.2 Carbon capture technologies.....	4
1.3 Oxygen transport membranes.....	5
1.3.1 Mechanism of oxygen transport	6
1.3.2 Membrane materials.....	8
1.4 Scope of the thesis.....	12
2 Phase and microstructural characterizations for $\text{Ce}_{0.8}\text{Gd}_{0.2}\text{O}_{2-\delta}$ - FeCo_2O_4 dual phase oxygen transport membranes	21
2.1 Introduction	22
2.2 Experimental.....	23
2.3 Results and discussion	28
2.3.1 Microstructure characterization	28
2.3.2 Phase characterization	31
2.3.3 Effect of microstructure parameters on ambipolar conductivity	34
2.4 Conclusions	38
Appendix A2.....	43

3 Mechanical reliability of $\text{Ce}_{0.8}\text{Gd}_{0.2}\text{O}_{2-\delta}\text{-FeCo}_2\text{O}_4$ dual phase membranes synthesized by one-step solid-state reaction	47
3.1 Introduction	48
3.2 Experimental.....	50
3.3 Results and discussion	55
3.3.1 Phase constituents and microstructure	55
3.3.2 Residual stress	60
3.3.3 Mechanical properties	63
3.3.4 Subcritical crack growth and Weibull analysis	66
3.3.5 Fractography	69
3.3.6 Reliability and lifetime analysis	75
3.4 Conclusions	78
Appendix A3.....	86
4 Optimization of sintering conditions for improved microstructural and mechanical properties of dense $\text{Ce}_{0.8}\text{Gd}_{0.2}\text{O}_{2-\delta}\text{-FeCo}_2\text{O}_4$ oxygen transport membranes	93
4.1 Introduction	94
4.2 Experimental.....	96
4.3 Results and discussion	99
4.3.1 Characterization of phase transformations	99
4.3.2 Microstructural investigations	101
4.3.3 Mechanical properties	104
4.4 Conclusions	109
Appendix A4.....	117

5 Micro-mechanical characterization of $\text{Ce}_{0.8}\text{Gd}_{0.2}\text{O}_{2-\delta}\text{-FeCo}_2\text{O}_4$ dual phase oxygen transport membranes	121
5.1 Introduction	122
5.2 Experimental.....	123
5.3 Results and discussion	125
5.3.1 Phase and microstructure characterizations	125
5.3.2 Mechanical properties	129
5.4 Conclusions	134
Appendix A5.....	139
6 Residual stress and mechanical strength of $\text{Ce}_{0.8}\text{Gd}_{0.2}\text{O}_{2-\delta}\text{-FeCo}_2\text{O}_4$ dual phase oxygen transport membranes	141
6.1 Introduction	142
6.2 Experimental.....	144
6.3 Results and discussion	148
6.3.1 Microstructure.....	148
6.3.2 Lattice constants	150
6.3.3 Residual stress	152
6.3.4 Fracture strength and fractography	158
6.4 Conclusions	163
Appendix A6.....	170

7 Enhancing oxygen permeation of solid-state reactive sintered $\text{Ce}_{0.8}\text{Gd}_{0.2}\text{O}_{2-\delta}\text{-FeCo}_2\text{O}_4$ composite by optimizing the powder preparation method.....	175
7.1 Introduction	176
7.2 Experimental.....	180
7.3 Results and discussion	183
7.3.1 Powder characteristics	183
7.3.2 Phase and microstructure characterizations	188
7.3.3 Oxygen permeation.....	193
7.4 Conclusions	204
Appendix A7	209
8 Reflections and perspectives	215
8.1 Introduction	216
8.2 Powder preparation.....	216
8.2.1 Powder composition	216
8.2.2 Powder synthesis methods	217
8.3 Sintering profiles.....	219
8.4 Mechanical stability after long-term operation	220
8.5 Conclusions	221

Acknowledgements

About the author

Energie & Umwelt / Energy & Environment
Band / Volume 529
ISBN 978-3-95806-527-7

Mitglied der Helmholtz-Gemeinschaft

