

## Long Term Stability and Permeability of Mixed Ion Conducting Membranes under Oxyfuel Conditions

Xiaoyu Li

Forschungszentrum Jülich GmbH  
Institute of Energy and Climate Research (IEK)  
Microstructure and Properties of Materials (IEK-2)

# **Long Term Stability and Permeability of Mixed Ion Conducting Membranes under Oxyfuel Conditions**

Xiaoyu Li

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

Band / Volume 194

---

ISSN 1866-1793

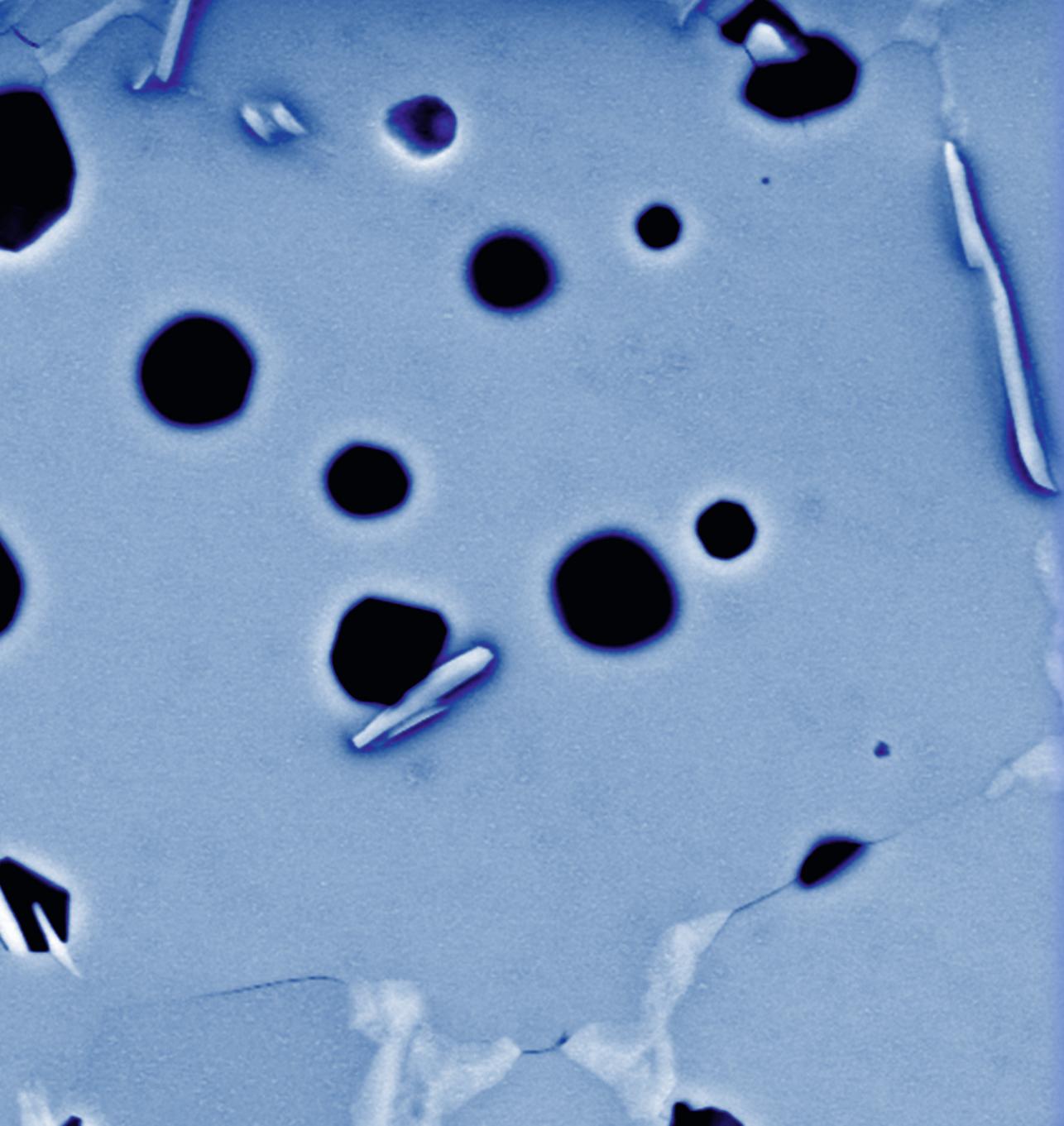
ISBN 978-3-89336-916-4

# Content

1	Introduction .....	1
2	Scope of work.....	3
3	Fundamentals .....	5
3.1	CO <sub>2</sub> capture and storage technologies.....	5
3.1.1	Pre-combustion process .....	5
3.1.2	Post-combustion process.....	7
3.1.3	Oxyfuel process .....	8
3.2	Mixed ionic and electronic conductors (MIEC).....	10
3.2.1	Materials structure of MIEC membranes.....	10
3.2.2	Thermochemical properties of MIEC membranes.....	13
3.3	Oxygen transport mechanisms .....	18
3.4	Membrane degradation .....	24
4	Materials and Experimental methods.....	27
4.1	Materials selection and production.....	27
4.1.1	Perovskite-structured Ba <sub>x</sub> Sr <sub>1-x</sub> Co <sub>y</sub> Fe <sub>1-y</sub> O <sub>3-δ</sub> (BSCF) .....	27
4.1.2	Powder production .....	28
4.1.3	Uni-axial dry pressing and sintering process .....	29
4.2	Methods for materials characterization .....	31
4.2.1	Differential thermal analysis (DTA) .....	31
4.2.2	Thermomechanical analysis (TMA) .....	32
4.2.3	Thermogravimetric analysis (TGA).....	34
4.2.4	X-ray diffraction analysis (XRD) .....	35
4.2.5	Scanning electron microscopy (SEM) .....	36
4.3	Determination of membrane permeability .....	37
4.3.1	Setup of permeation tests .....	37
4.3.2	Performance of oxygen permeation measurements .....	39
4.4	Thermal stability evaluation of membrane materials .....	41
5	Results and discussion.....	43
5.1	Characterization of membrane materials.....	43
5.1.1	Prediction of structural stability of perovskite oxides .....	43
5.1.2	Phase characterization.....	46

5.1.3	Chemical composition analysis .....	49
5.1.4	Particle size distribution.....	49
5.2	Sintering behaviour of BSCF materials.....	50
5.2.1	Melting temperature.....	51
5.2.2	Measurement of shrinkage curves .....	52
5.2.3	Relative density of sintered samples.....	57
5.2.4	Determination of sintering temperature and dwell time .....	58
5.3	Thermochemical properties of membrane materials .....	62
5.3.1	Variation of oxygen nonstoichiometry .....	62
5.3.2	Thermochemical expansion behaviour .....	63
5.4	Long-term oxygen permeability of BSCF membranes .....	66
5.4.1	Long-term permeation measurement at 850 °C .....	66
5.4.2	Long-term permeation measurement at 800 °C .....	73
5.4.3	Influence of cations on the permeation stability of BSCF membranes .....	84
5.4.4	Temperature effect on the permeation stability of BSCF membranes.....	88
5.4.5	Influence of membrane thickness on the permeation stability of BSCF membranes .....	90
5.5	Cyclic permeation measurement of BSCF membranes.....	92
5.6	Characterisation of thermochemical stability of BSCF materials .....	99
5.6.1	Phase decomposition of BSCF materials at 850 °C.....	100
5.6.2	Phase decomposition of BSCF materials at 800 °C.....	103
5.6.3	Growth kinetics of hexagonal phase .....	106
6	Conclusions .....	111
	References.....	115
	Symbol index .....	125
	Figure index .....	129
	Table index .....	133
	Appendix.....	135
A	Raw materials and calcination parameters for powder production .....	135
B	Pressing steps for pellets/membranes production .....	136
C	Melting temperature determination.....	137
D	Data of the ions in BSCF materials .....	138
E	EDX analysis of the 2.0 mm-thick BSCF6482 membrane after 2000 h permeation at 850 °C under the air/He pressure gradient .....	139

F Linescans of the 2.5 mm-thick BSCF4682 membrane after 2000 h permeation at 800 °C under the air/He pressure gradient .....	140
G SEM and EDX analysis of the secondary phases in the BSCF6482 membrane after long-term and cyclic permeation measurement.....	141
Acknowledgements.....	143



**Energie & Umwelt / Energy & Environment  
Band / Volume 194  
ISBN 978-3-89336-916-4**

