Supplementary Information (SI) for Journal of Materials Chemistry A.

Supplementary information

Revisiting the ionic conductivity of solid oxide electrolytes: A technical review

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Table S1. The thin-film conductivities of different electrolyte classes obtained for SOFCs and SOECs under open circuit voltage conditions in the intermediate temperature range. The conductivity data were calculated as follows: $\sigma = h \cdot R_{ohm}$, were h is the electrolyte thickness, R_{ohm} is the ohmic resistance determined from the electrochemical impedance spectroscopy data.

Electrolyte		Ohmic resistance (Ω cm^2)			Conductivity (mS cm^{-1})			Ref.
Composition	**Thickness (μm)**	**500 °C**	**600 °C**	**700 °C**	**500 °C**	**600 °C**	**700 °C**	
YSZ + symmetric GDC films	10	–	–	0.1	–	–	7.9	S1
YSZ + symmetric GDC films	10	–	–	0.1	–	–	8.2	S1
YSZ + symmetric GDC films	10	–	–	0.1	–	–	9.5	S1
YSZ + GDC	18	–	1.7	0.7	–	1.0	2.6	S2
YSZ + GDC	10	–	0.2	0.1	–	5.9	8.0	S3
YSZ + GDC	4	–	0.1	0.1	–	3.3	4.0	S4
YSZ + GDC	5	–	–	0.2	–	–	2.4	S5
YSZ + SDC	10	–	0.5	0.2	–	2.1	6.3	S6
YSZ + GDC	10	–	0.7	0.2	–	1.5	4.5	S6
YSZ + GDC	10	–	–	0.3	–	–	3.6	S7
YSZ + GDC	3	–	–	0.1	–	–	3.0	S8
YSZ + GDC	10	–	0.6	0.3	–	1.7	4.0	S9
YSZ + LDC	10	–	0.5	0.2	–	2.0	4.3	S9
YSZ + GDC	260	–	–	2.0	–	–	12.9	S10
YSZ + GDC	2.5	–	0.6	0.2	–	0.4	1.0	S11
YSZ + GDC	10	–	0.4	0.3	–	2.4	3.8	S12
YSZ + GDC	5.8	–	–	0.2	–	–	2.6	S13
YSZ + GDC	20	–	2.1	0.6	–	1.0	3.3	S14
YSZ + SDC	6	–	–	0.1	–	–	5.0	S15
YSZ + GDC	5	–	0.3	0.2	–	1.7	3.3	S16
YSZ + GDC	10	–	0.3	0.1	–	3.6	7.1	S17
YSZ + GDC	20	–	–	0.3	–	–	8.0	S18
YSZ + SDC	7.6	–	–	0.2	–	–	4.8	S19
YSZ + GDC	8	–	–	0.3	–	–	3.1	S20
YSZ + GDC	19	–	–	0.2	–	–	8.6	S21
YSZ + GDC	16		2.0	1.3		0.8	1.2	S22
YSZ + SDC	10.6			0.6			1.9	S23
GDC + YSZ + GDC	1.3	0.1	0.0	–	1.6	7.8	–	S24
ScCeSZ + GDC0.1	6	–	–	0.7	–	–	0.8	S25
ScSZ	0.3	0.3	–	–	0.1	–	–	S26
ScSZ	15	–	–	0.5	–	–	3.1	S27

Electrolyte		Ohmic resistance (Ω cm^2)			Conductivity (mS cm^{-1})			Ref.
Composition	Thickness (μm)	500 °C	600 °C	700 °C	500 °C	600 °C	700 °C	
ScSZ	12	–	–	0.2	–	–	8.0	S28
ScCeSZ	15	–	0.6	0.4	–	2.6	3.9	S29
CeSSZ	35	–	0.7	0.3	–	4.9	13.0	S30
GDC/ScSZ	4	–	0.5	0.3	–	0.9	1.5	S31
ScSZ/SDC	5	–	–	0.3	–	–	1.6	S32
GDC–ScSZ	25	0.3	0.2	0.2	8.6	11.9	13.9	S33
BCZYYb	14	0.3	0.1	–	5.0	10.0	–	S34
BCZYYb	14	–	0.2	0.1	–	7.9	12.2	S34
BCZYYb	11.8	0.4	0.2	–	3.1	4.8	–	S35
BCZYYb	11.8	0.4	0.3	–	2.8	4.0	–	S35
BCZYYb	21	–	0.5	0.3	–	4.5	6.9	S36
BCZYYb4411	21	–	0.5	0.3	–	4.5	6.8	S36
BCZYYb4411	21	–	0.4	0.2	–	5.7	8.6	S36
BCZYYb4411	21	–	0.5	0.3	–	4.3	6.5	S36
BCZYYb4411	6	0.2	0.2	–	2.5	3.6	–	S37
BZCYY	6	0.3	–	–	2.0	–	–	S37
BZCYY	6	0.3	0.2	–	1.7	2.6	–	S37
BZCYY	6	0.4	–	–	1.3	–	–	S37
BZCYY	6	0.2	0.1	–	3.0	4.6	–	S37
BZCYY	6	0.3	–	–	2.3	–	–	S37
BZCYY	15	1.0	0.4	–	1.6	3.7	–	S38
BCZYYb	15	–	0.3	–	–	5.2	–	S38
BCZYYb	15	–	0.3	–	–	5.8	–	S38
BCZYYb	25	0.9	0.6	–	2.7	4.3	–	S39
BCZYSm13	11	0.9	0.5	–	1.2	2.0	–	S40
BCZYYb	11	0.6	0.4	–	1.8	3.0	–	S40
BCZYYb	11	0.5	0.3	–	2.1	3.5	–	S40
BCZYYb	11	0.3	0.2	–	3.4	5.9	–	S40
BCZYYb	11	0.4	0.2	–	2.5	4.8	–	S40
BCZYYb	22	–	0.5	0.3	–	4.5	7.1	S41
BCZYYb4411	22	–	0.4	0.3	–	5.2	7.7	S41
BCZYYb4411	12	0.6	0.4	0.3	1.9	2.9	3.8	S42
BCZYYb	12	0.6	0.4	0.3	2.0	3.0	4.6	S42
BCZYYb0.95	15	–	0.4	0.2	–	4.2	6.3	S43
BZCY	15	2.3	1.6	1.5	0.7	0.9	1.0	S44

Electrolyte		Ohmic resistance (Ω cm^2)			Conductivity (mS cm^{-1})			Ref.
Composition	Thickness (µm)	500 °C	600 °C	700 °C	500 °C	600 °C	700 °C	
BCZYYb	16	–	0.9	–	–	1.8	–	S45
SZCY541	10	0.3	0.3	–	3.2	3.6	–	S46
BCZYYb	8	0.6	–	–	1.2	–	–	S47
BCZYYb4411	17	0.6	0.4	0.3	2.7	4.5	6.5	S48
BZCYYb(1%NiO)	45	–	0.3	0.2	–	17.3	30.0	S49
BZCY7	21	–	0.2	0.2	–	8.5	11.8	S50
BZCYYb	15	0.6	0.4	0.3	2.5	3.7	5.4	S51
BCZY44	5	0.5	0.6	–	1.0	0.8	–	S52
SDC	300	–	–	0.5	–	–	61.2	S53
SDC	14	1.7	0.7	–	0.8	2.0	–	S54
GDC0.1	20	0.5	0.2	–	4.3	10.2	–	S55
GDC0.1	20	0.3	0.2	–	5.9	11.6	–	S55
GDC	8	–	0.2	0.2	–	3.3	4.5	S56
GDC	15	–	–	0.3	–	–	5.0	S57
GDC	174	–	–	0.7	–	–	24.9	S58
SDC	300	–	–	0.5	–	–	62.5	S59
GDC	320	–	–	0.2	–	–	160.0	S60
SDC	10	0.5	0.3	–	2.2	3.7	–	S61
SDC	30	0.6	0.3	0.2	4.9	11.5	16.7	S62
GDC	7		0.1	0.5		6.9	1.6	S63
SDC	10	–	0.3	0.1	–	3.0	8.1	S64
SmNdDC	190	–	0.9	0.4	–	21.6	52.8	S65
LSGM	300	–	–	0.4	–	–	78.9	S66
LSGM’	19	0.4	0.2	–	5.1	11.2	–	S67
LSGM	9.8	–	0.4	0.2	–	2.5	4.4	S68
SDC + LSGM0.2 + SDC	20	–	0.1	0.1	–	14.3	33.3	S69
LSGM	150	–	0.5	0.2	–	31.3	65.2	S70
LSGM0.2	50	–	0.3	–	–	15.6	–	S71
LSGM	25	2.3	0.8	0.7	1.1	3.1	3.8	S72
LSGM	19	–	0.3	0.1	–	5.8	15.8	S73
LSGM + LDC46 + LDC	23	–	0.5	0.2	–	4.4	10.5	S74
LDC46 + LSGM + LDC46	3.4	–	–	0.1	–	–	2.4	S75
LSGM’’	50	–	0.3	0.2	–	18.5	31.3	S76
LSGM0.2	500	–	–	1.0	–	–	52.1	S77
LSGM’’’ + SDC	40	–	1.4	1.0	–	2.8	3.8	S78

Electrolyte		Ohmic resistance (Ω cm^2)			Conductivity (mS cm^{-1})			Ref.
Composition	Thickness (μm)	500 °C	600 °C	700 °C	500 °C	600 °C	700 °C	
LSGM	39	1.7	0.6	0.3	2.2	6.6	15.6	S79
LSGM	17	0.2	0.1	–	11.3	22.7	–	S80
LSGM0.2	40	–	–	0.2	–	–	20.0	S81
LSGM’	200	–	0.8	0.2	–	26.0	85.8	S82
LSGM8282	300	–	–	0.3	–	–	93.8	S83
LSGM	75	–	–	0.2	–	–	32.6	S84
BZYN	12	1.2	0.6	0.3	1.0	2.0	4.6	S85
BZY20	20	–	0.4	–	–	4.5	–	S86
BZY20	35	1.6	0.7	0.5	2.2	5.4	6.6	S87
BZY20	20	–	1.5	0.7	–	1.4	2.9	S88
BZY20	30	–	1.3	0.6	–	2.3	5.4	S89
BZY20	25	–	3.2	–	–	0.8	–	S90
BZYZ	20	–	1.2	–	–	1.7	–	S91
BZY20	5	–	0.9	0.5	–	0.5	1.0	S92
BZY20	16	–	–	1.0	–	–	1.6	S93
BZY20	23	–	1.7	–	–	1.3	–	S94
BZYCa	15	–	1.6	0.8		1.0	2.0	S95
BZYCa’	25	2.4	1.8	1.0	1.0	1.4	2.6	S96
BZY20	4	4.7	2.0	–	0.1	0.2	–	S97
BZYIn	12	–	0.6	0.3	–	2.1	3.5	S98
BZYSm	25	–	1.8	1.0	–	1.4	2.6	S99

Electrolytes: GDC = $Ce_{0.8}Gd_{0.2}O_{2-\delta}$, BCZYYb = $BaZr_{0.1}Ce_{0.7}Y_{0.1}Yb_{0.1}O_{3-\delta}$, BCZYYb4411 = $BaCe_{0.4}Zr_{0.4}Y_{0.1}Yb_{0.1}O_{3-\delta}$, BZCYY = $BaZr_{0.5}Ce_{0.3}Y_{0.1}Yb_{0.1}O_{3-\delta}$, BCZYSm13 = $BaCe_{0.7}Zr_{0.1}Y_{0.07}Sm_{0.13}$O3–δ, BCZYYb0.95 = $Ba(Zr_{0.1}Ce_{0.7}Y_{0.1}Yb_{0.1})_{0.95}O_{3-\delta}$, BZCY = $BaZr_{0.1}Ce_{0.7}Y_{0.2}O_{3-\delta}$, SZCY541 = $SrZr_{0.5}Ce_{0.4}Y_{0.1}O_{3-\delta}$, LDC = $Ce_{0.9}La_{0.1}O_{1.95}$, LCP = La/Pr co-doped CeO_2 = $La_{0.33}Ce_{0.62}Pr_{0.05}O_{2-\delta}$, SDC = $Sm_{0.2}Ce_{0.8}O_{1.9}$, LSGM = $La_{0.9}Sr_{0.1}Ga_{0.8}Mg_{0.2}O_3$, ScCeSZ = $(Sc_2O_3)_{0.10}$ $(CeO_2)_{0.01}$ $(ZrO_2)_{0.89}$, CeSSZ = 1 mol% CeO_2 codoped 10 mol % Sc_2O_3–ZrO_2, $GDC_{0.1}$ = $Gd_{0.1}Ce_{0.9}O_{1.95}$, BCZY44 = $BaCe_{0.4}Zr_{0.4}Y_{0.2}O_{3-\delta}$, BZCY7 = $BaZr_{0.1}Ce_{0.7}Y_{0.2}O_{3-\delta}$, LSGM0.2 = $La_{0.8}Sr_{0.2}Ga_{0.8}Mg_{0.2}O_3$, BZYN = $BaZr_{0.76}Y_{0.2}Ni_{0.04}O_{3\delta}$, SmNdDC = $Sm_{0.075}Nd_{0.075}Ce_{0.85}O_{2-\delta}$, LSGM’ = $La_{0.8}Sr_{0.2}Ga_{0.83}Mg_{0.17}O_{3-\delta}$, LDC46 = $Ce_{0.6}La_{0.4}O_{2-\delta}$, LSGM’’ = $La_{0.87}Sr_{0.13}Ga_{0.88}Mg_{0.12}O_{3-\delta}$, LSGM’’’ = $La_{0.88}Sr_{0.12}Ga_{0.82}Mg_{0.18}O_{3-\delta}$, LSGM8282 = $La_{0.8}Sr_{0.2}Ga_{0.8}Mg_{0.2}O_3$, BZYZ = $BaZr_{0.8}0Y_{0.16}Zn_{0.04}O_{3-\delta}$, BZYZCa = $BaZr_{0.8}Y_{0.15}Ca_{0.05}O_{3-\delta}$, BZYCa’ = $BaZr_{0.8}Y_{0.2}O_{3-\delta}$ + 4 mol%CaO, BZYIn = $BaZr_{0.8}Y_{0.15}In_{0.05}O_{3-\delta}$, BZYSm = $BaZr_{0.8}Y_{0.15}Sm_{0.05}O_{3-\delta}$

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