Supporting information

New zinc and bismuth doped glass sealants with substantially suppressed boron deposition and poisoning for solid oxide fuel cells

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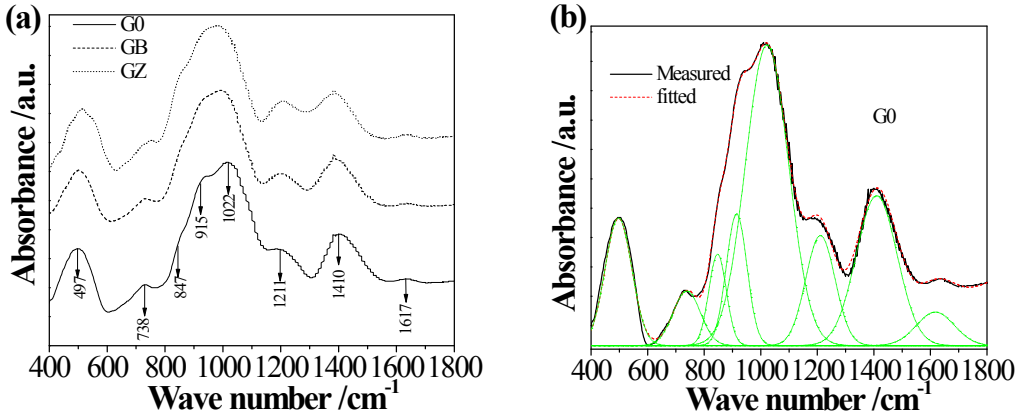
Experimental

Infrared spectra of glass powders were recorded at room temperature in the range 400-1800 cm^{-1} using a spectrometer (FT-IR, model NiCOLET5700).

Results and Discussion

FT-IR results of the glass samples:



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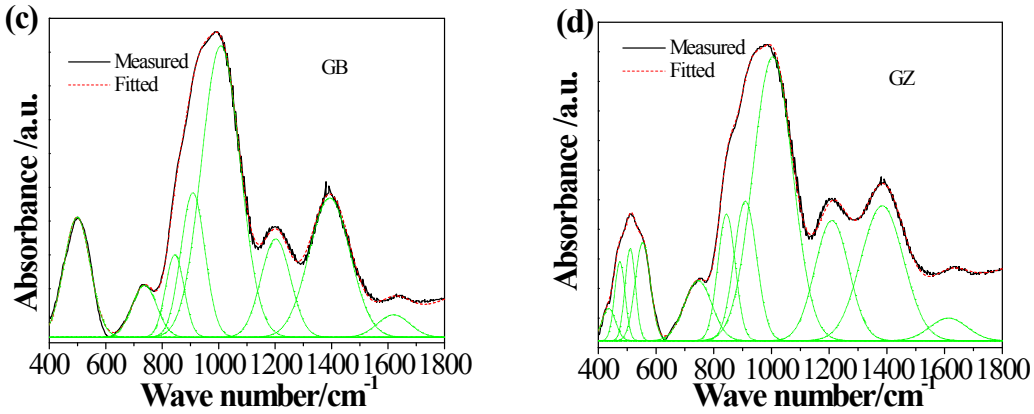

Figure S1. (a) FT-IR spectra of quenched glass samples and deconvoluted spectra for (b) G0, (c) GB, and (d) GZ.

Table S1. The assignments of vibrational modes in FT-IR spectra.

Wave number (cm^{-1})	FT-IR Assignment
423~450	Overlapped bending modes of Si-O-Si and B-O-B linkages.[1, 2]
475~487	Si-O-Si, Si-O-B isolated vibrations.[3]
440~520	Deformation vibrational modes of Si–O–Si links.[4]
440~470	Bridging oxygen bending in the Si network.[5]
480~488	Si-O-Si rocking.[2]
498~508	Stretching vibrations of Bi–O bonds in strongly distorted vibrations $[BiO_6]$ units.[5-7]
554	Stretching vibrations of $[ZnO_4]$ units.[1, 8]
720~780	Oxygen bridges between one tetrahedral and one trigonal boron atom.[4]
840	Stretching vibrations of the non-bridging oxygens (NBOs) of $[BO_4]$ groups.[8]
897~909	Asymmetric vibration of B–O–Si units.[3]
995~1014	Stretching vibrations of B-O bonds in $[BO_4]$ units from tri-, tetra- and pentaborate groups.[6]
1012~1022	Stretching vibrations modes of $[SiO_4]$ and $[BO_4]$ units.[2]
917~1030	B-O stretching vibrations of $[BO_4]$ tetrahedra. [8]
1200~1300	$B\text{-}O^-$ non-bridging stretching in $[BO_3]$.[5, 7]
1396~1450	Symmetric stretching relaxation of B-O band of triangle $[BO_3]$ units.[2, 4, 9]
~1650	The [OH] mode of molecular water.[9]

Table S2. The assignments of vibrational modes in Raman spectra.

Wave number (cm^{-1})	Vibration mode
208~254	Bi–O "breathing" in [BiO_3] pyramidal like unit.[10]
250~254	Zn–O tetrahedral bending vibrations of [ZnO_4] units.[11, 12]
~360	Rocking motion of silicate units and/or motion of cationic polyhedral.[13]
350~375	Stretching Bi–O–Bi vibration of the distorted [BiO_6] octahedral units.[14, 15]
467~508	Q^3 units and/or mode of B–O–B, B–O–Si, and Si–O–Si linkages.[16]
572	vibration of [BO_4].[14]
620~647	Si-O symmetric stretching vibrations in various silicate units (mainly Q^2 units).[13, 16]
677~ 704	Q^1 units along with some metaborate units.[16]
700-709	B-O-B bending in [BO_3].[5]
~780	[BO_4] tetrahedral units with non-bridging oxygen atoms .[6, 13, 16]
850~875	Q^0 units.[16]
850	Q^0 group or structural defects Al-O-Si.[17]
890~926	Bi–O^- stretching vibration [BiO_3]. [5]
943~1003	Q^2 units.[13, 16, 17]
950–1000	Stretching motion of the Q^2 units.[13, 16, 17]
1050 ~1105	Q^3 units.[13, 16]
1143~1180	Q^4 units .[16]
1200 ~1450	Vibrations of B-O^- bond in [BO_3] units.[14]

XRD results of glass samples heat-treated at 750°C for 2 h:

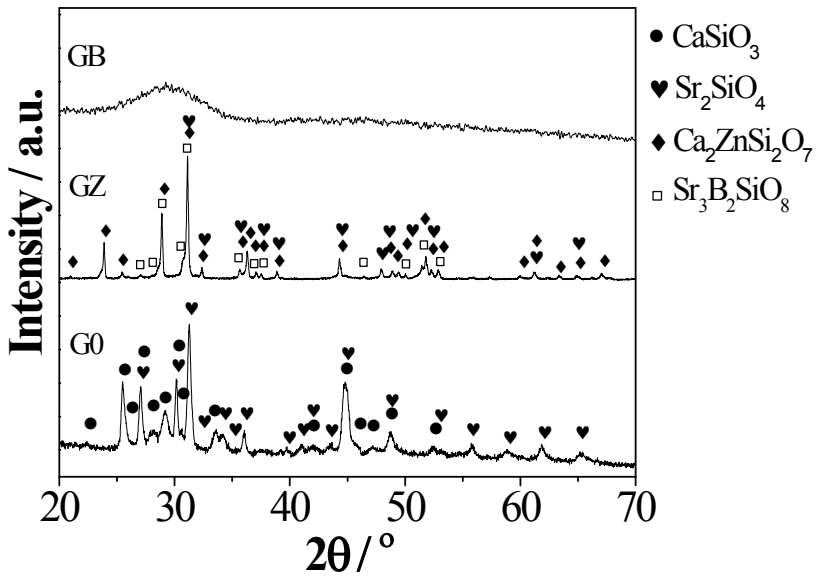

Figure S2. XRD patterns of glass samples after the heat-treatment at 750°C for 2 h.

Electrochemical performance of a 6-µm-thick LSCF cathode:

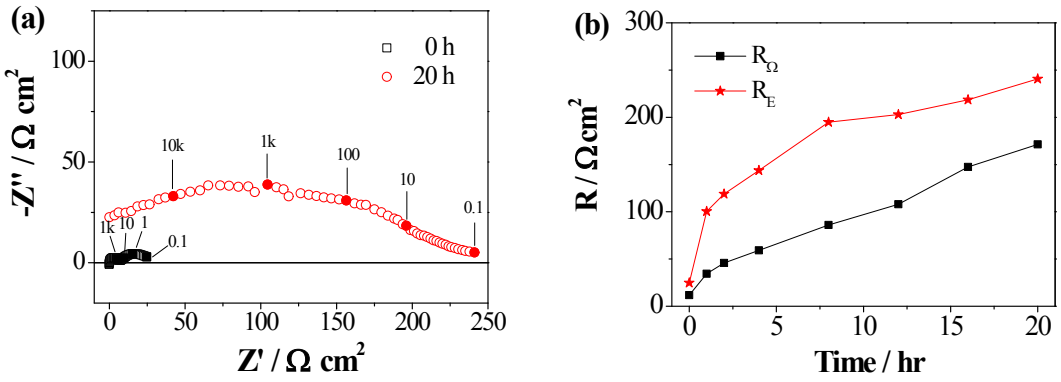

Figure S3. (a) Electrochemical impedance curves and (b) plots of R_E and R_Ω for the O_2 reduction reaction on a LSCF cathode under cathodic current passage at 200 mA cm^{-2} and 700°C for 20 h in the presence of G0 glass. The thickness of the LSCF electrode was 6 µm.

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