Nickel-substituted $Ba_{0.5}Sr_{0.5}Co_{0.8}Fe_{0.2}O_{3-\delta}$: a highly active perovskite oxygen electrode for reduced-temperature solid oxide fuel cells

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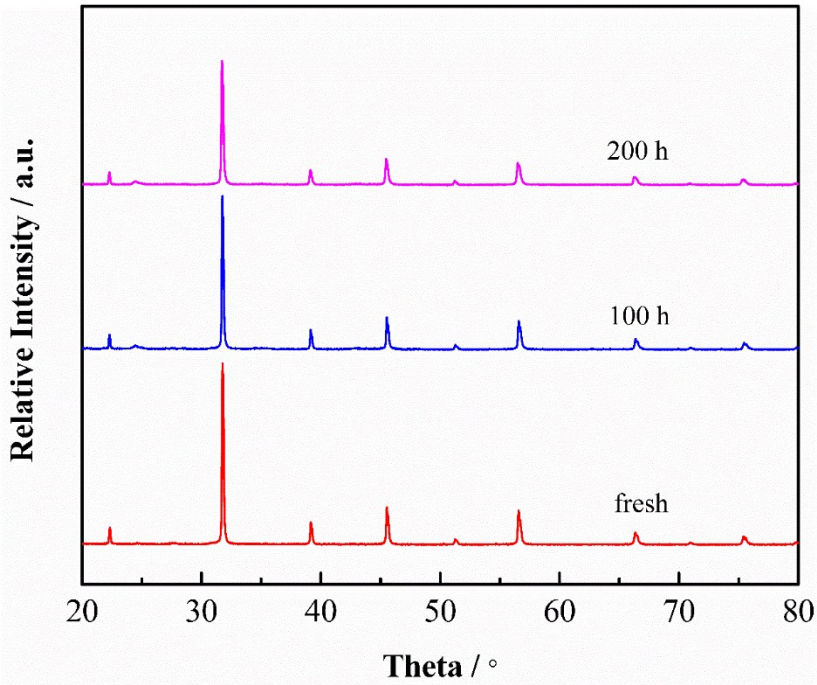

Fig. S1 XRD patterns of as-synthesized BSCFN after annealing at 600 °C for 100 and 200 h under an air atmosphere.

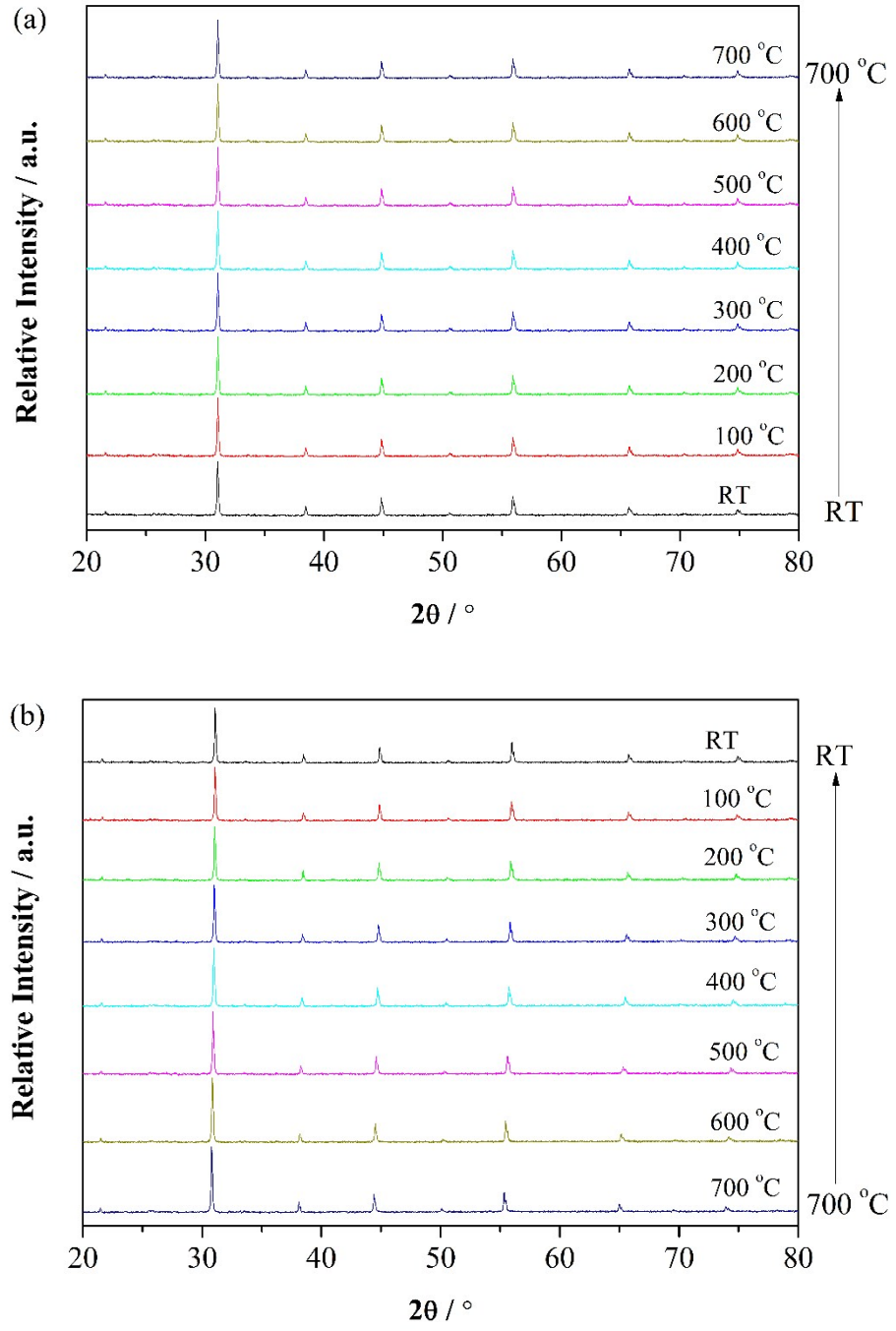

Fig. S2 HT-XRD patterns of BSCFN powder: (a) heating from room temperature to 700 °C, (b) cooling from 700 °C to room temperature.

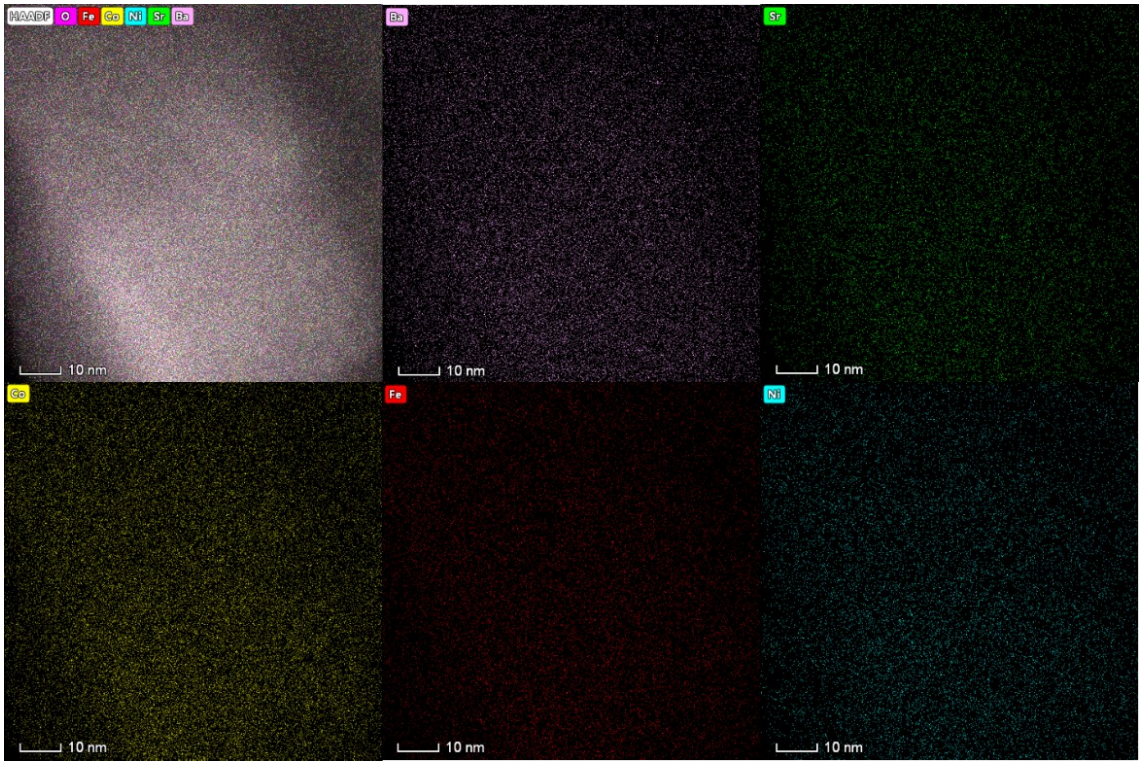

Fig. S3 EDX mappings of Ba, Sr, Co, Fe, and Ni in BSCFN sample.

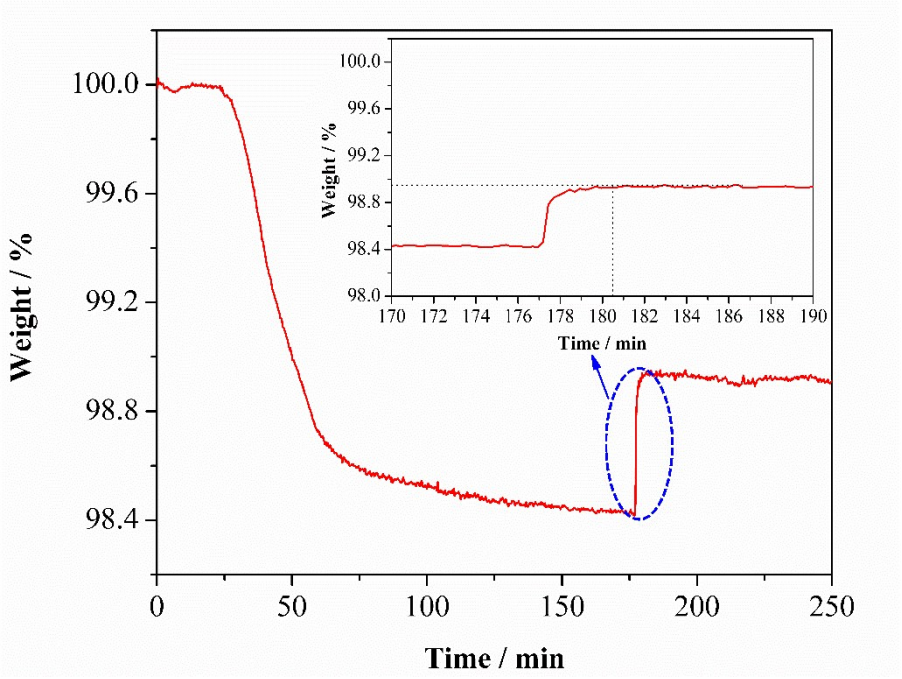

Fig. S4 Weight change of BSCFN sample after a sudden change in ambient atmosphere from argon to air.

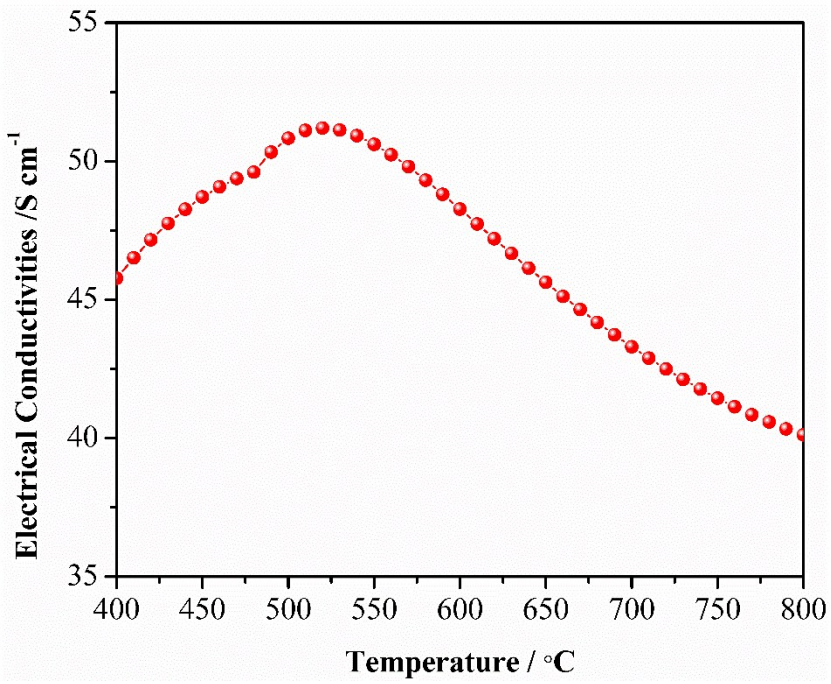

Fig. S5 Electrical conductivity of BSCFN sample using 4-probe DC method as a function of temperature.

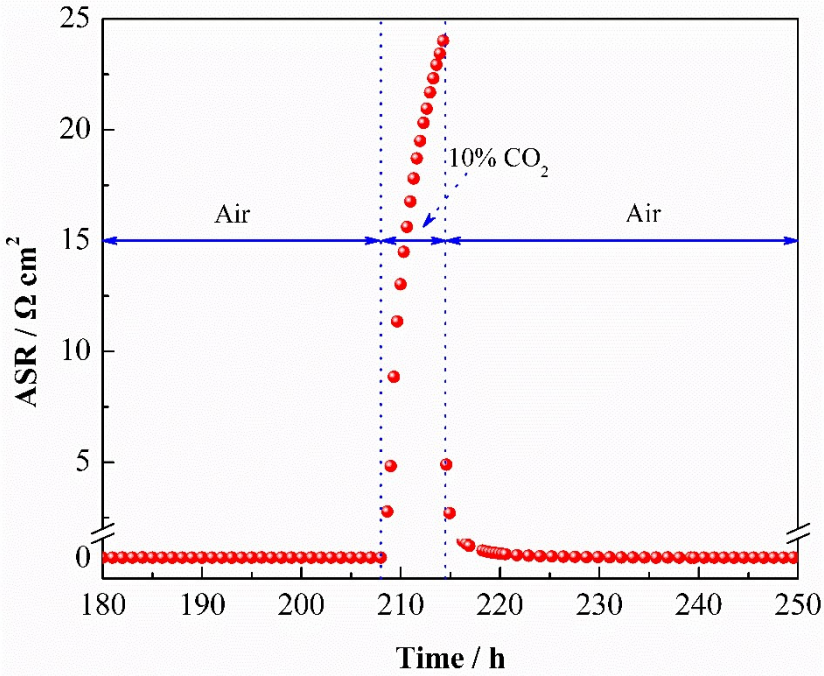

Fig. S6 Time-dependent polarization ASRs of BSCFN at 600 °C in air, 10 vol.% CO_2, and air, respectively.

Table S1 Crystallographic details of BSCFN obtained from the Rietveld refinement of XRD data.

Atom	**Site**	***x***	***y***	***z***	**Occupancy**	**U_{iso} (Å^2)**
Ba	1*a*	0	0	0	0.5026	0.06641
Sr	1*a*	0	0	0	0.4991	0.02865
Co	1*b*	0.5	0.5	0.5	0.6896	0.07558
Fe	1*b*	0.5	0.5	0.5	0.2001	0.02532
Ni	1*b*	0.5	0.5	0.5	0.1000	0.03014
O	3*d*	0.5	0.5	0	0.8949	0.10598

Table S2 Comparison of maximum power densities of the single cell with highly active cathode materials.

Anode	**Electrolyte**	**Cathode**	**Power Density (mW cm^{-2}) @600 °C**	**Ref.**
Ni+GDC	GDC	$La_{0.85}Sr_{0.15}MnO_{3\pm\delta}$-$(Bi_{0.8}Er_{0.2})_2O_3$	1180	1
Ni+YSZ	YSZ	$Bi_{0.5}Sr_{0.5}Fe_{0.9}Sb_{0.1}O_{3-\delta}$	950	2
Ni+YSZ	YSZ	$La_{1-x}Sr_xMnO_3$-$Bi_{1.6}Er_{0.4}O_3$	~550	3
Ni+YSZ	YSZ	$SrFe_{0.85}Ti_{0.1}Ni_{0.05}O_{3-\delta}$	684	4
Ni+YSZ	YSZ	Pr_6O_{11}	~230	5
Ni+GDC	GDC	$BaCoO_{3-x}$-$PrCoO_{3-x}$-$PrBa_{0.8}Ca_{0.2}Co_2O_{5+\delta}$	~1200	6
Ni+GDC	GDC	$La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$-$Ce_{0.9}Gd_{0.1}O_{2-\delta}$	800	7
Ni+YSZ	YSZ	$La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.7}Nb_{0.1}O_{3-\delta}$-$Er_{0.4}Bi_{1.6}O_3$	240	8
Ni+BZCYYb	SDC	$PrBa_{0.8}Ca_{0.2}Co_2O_{5+\delta}$	~590	9
Ni+SDC	SDC	BSCF	1010	10
Ni+SDC	**SDC**	**BSCFN**	**1317**	**This work**

Supplementary References

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