Electronic Supplementary Material (ESI) for Energy & Environmental Science.

Electronic Supplementary Information

Zr and Y co-doped perovskite as a stable, high performance cathode for solid oxide fuel cells operating below 500 °C

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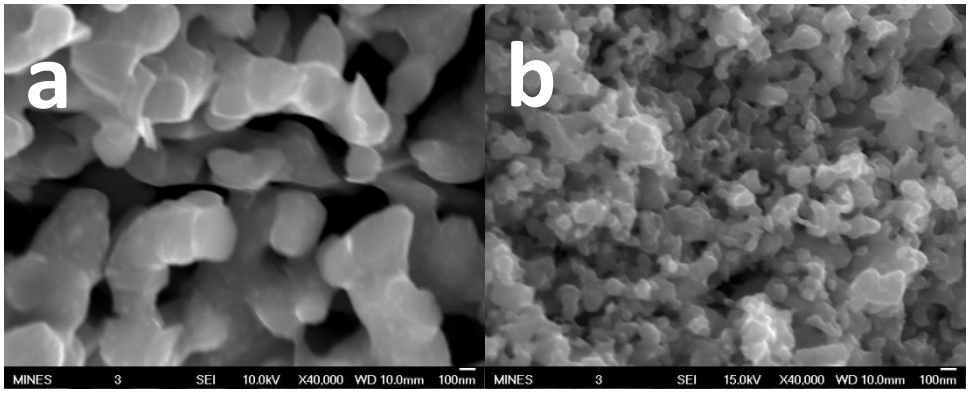


Figure S1 (a) SEM image of BSCF symmetric cell before testing (b) SEM image of BCFZY0.1 symmetric cell before testing

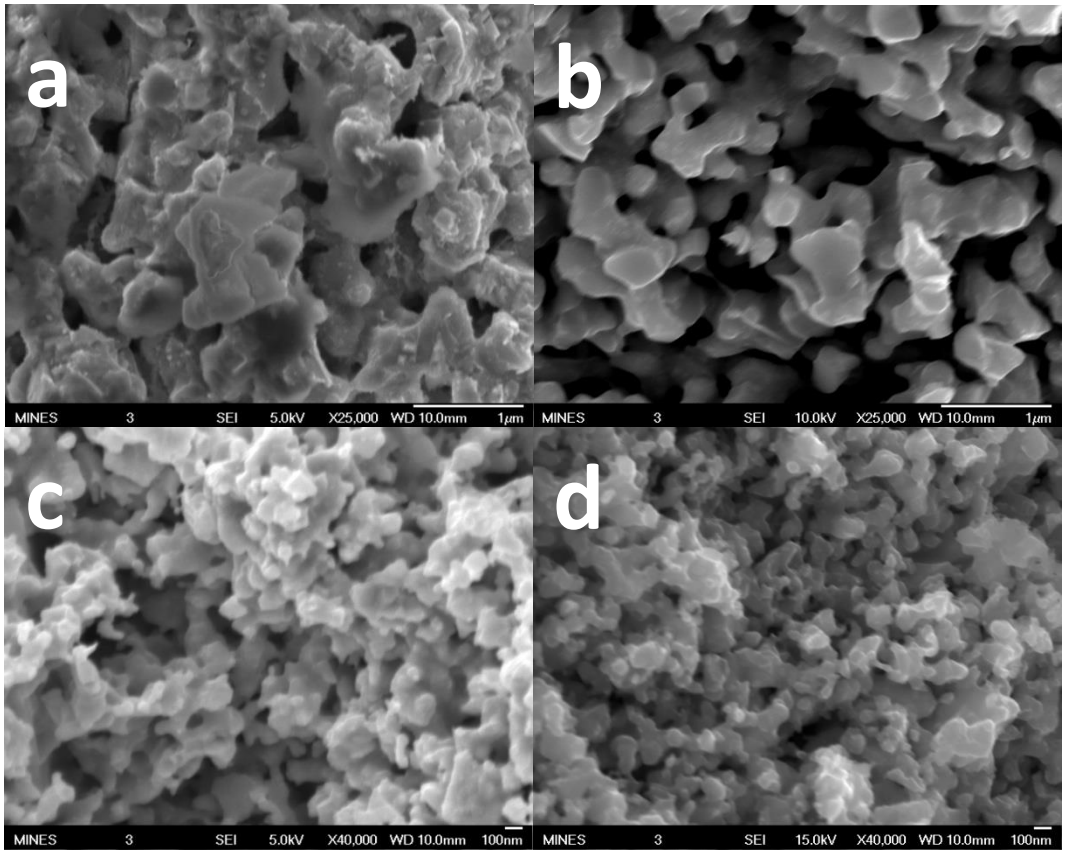


Figure S2 (a) SEM image of BSCF symmetric cell after 720 hours operation at 350 °C under air, (b) SEM image of BSCF symmetric cell before testing, (c) SEM image of BCFZY0.1 symmetric cell after 1000 hours operation t 350 °C under air, (d) SEM image of BCFZY0.1 symmetric cell before testing.

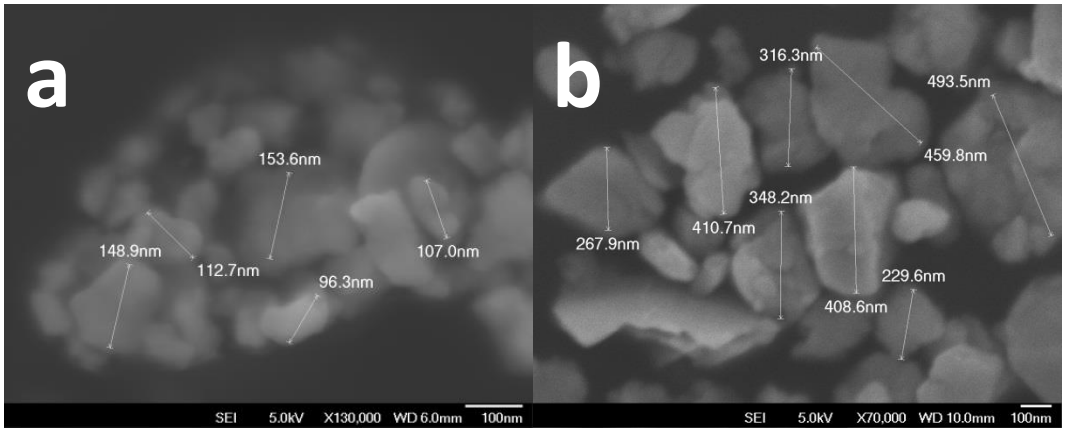


Figure S3 (a) SEM image of BCFZY0.1 powder calcined at 900 °C for 5 hours (b) SEM image of BSCF powder calcined at 900 °C for 5 hours.

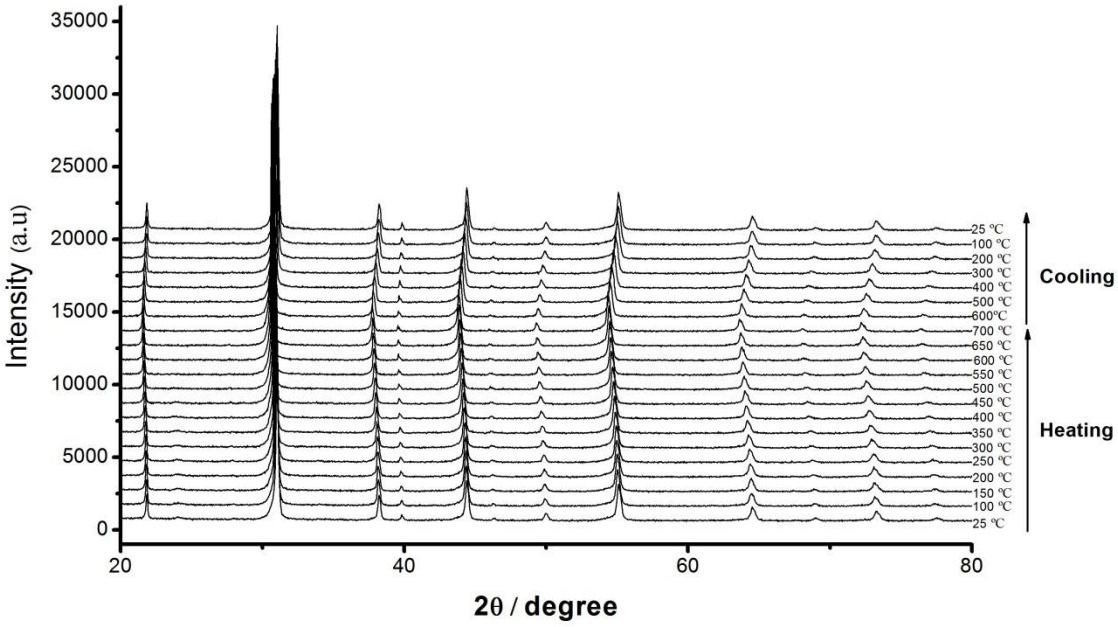


Figure S4 XRD patterns of BCFZ under study during heating and cooling.

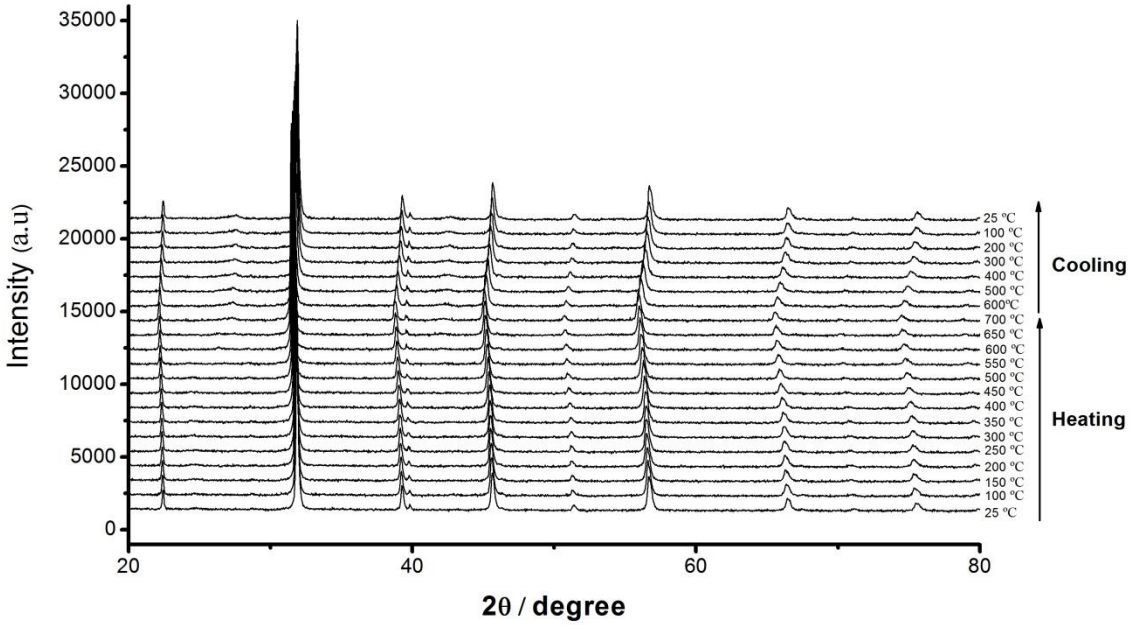


Figure S5 XRD patterns of BSCF under study during heating and cooling.

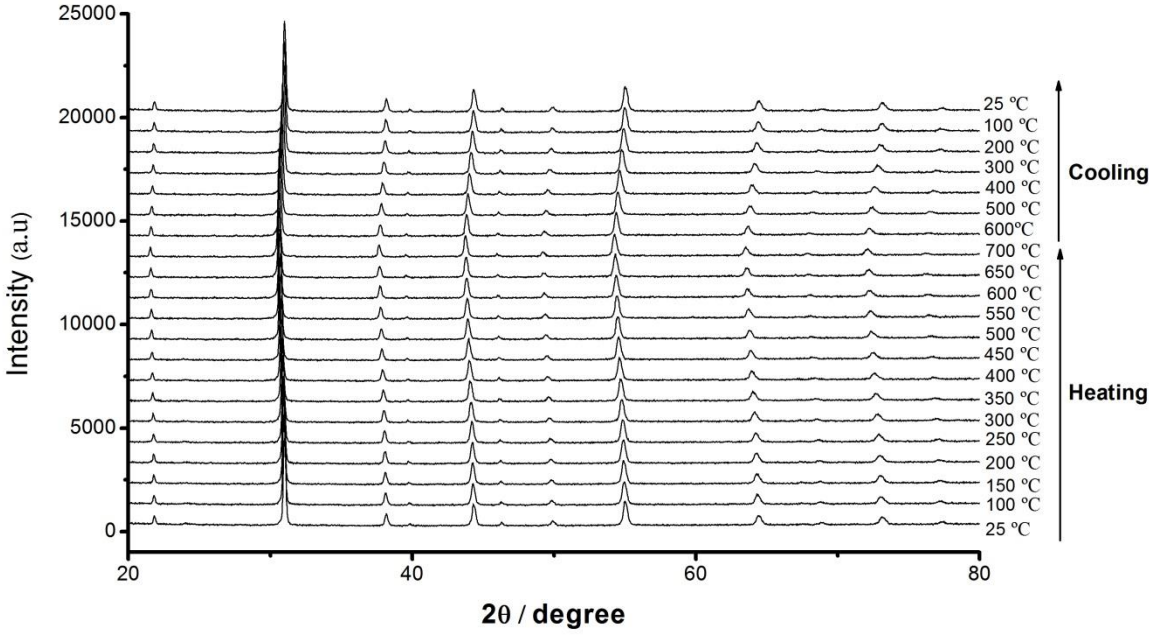
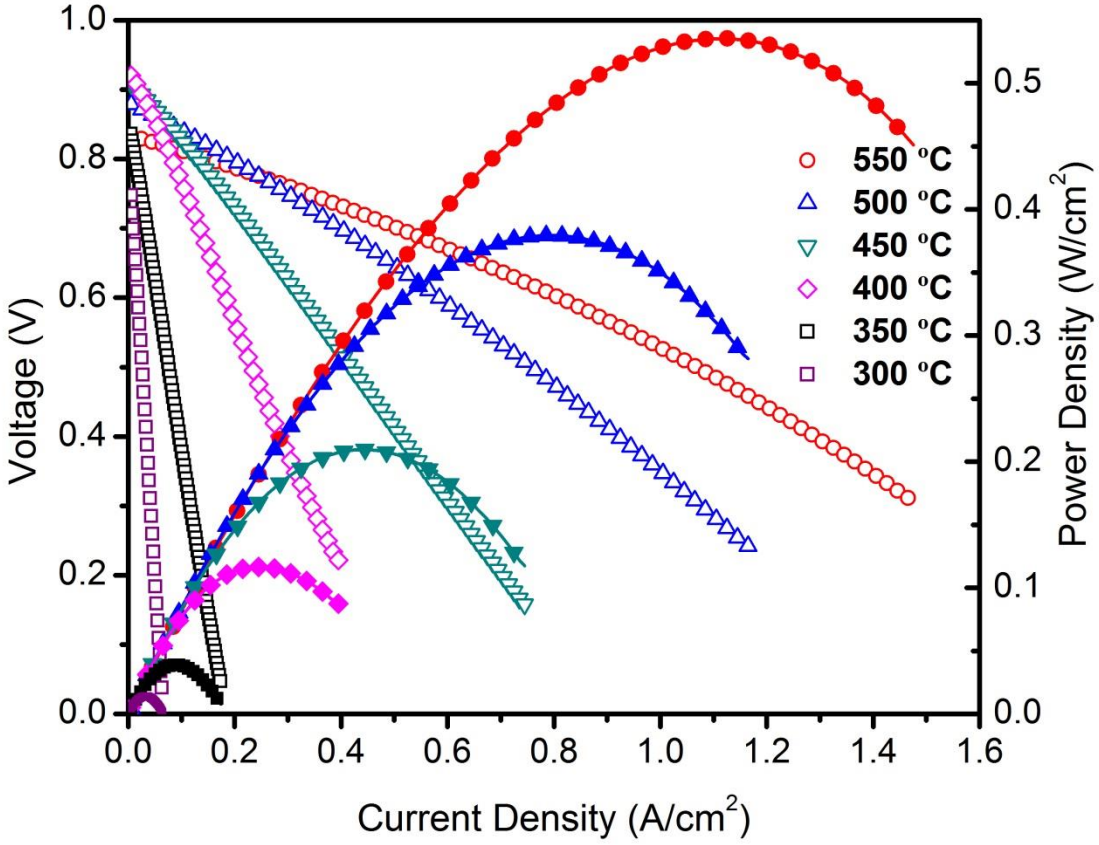


Figure S6 XRD patterns of BCFZY0.1 under study during heating and cooling .



Figue S7 I-V and corresponding I-P curves of unoptimized cell #1 with BCFZY0.1 as cathode under H_2/Air at 550 °C to 300 °C.

The anode thicknees of unoptmized cell #1 is 1.2mm while the thickness of cell #2 is 0.4 mm. The electrolyte and cathode thickness are the same.

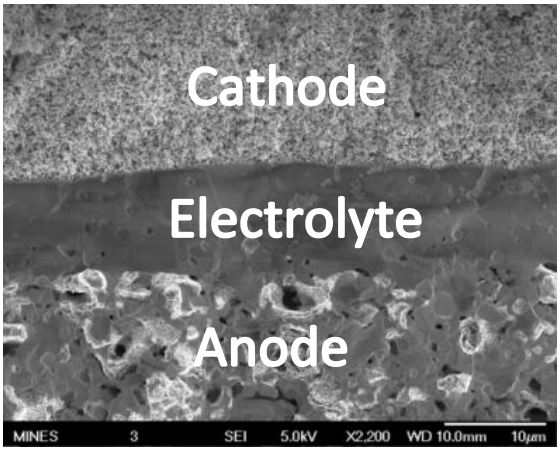


Figure S8 Cross section SEM image of cell #2 after testing.

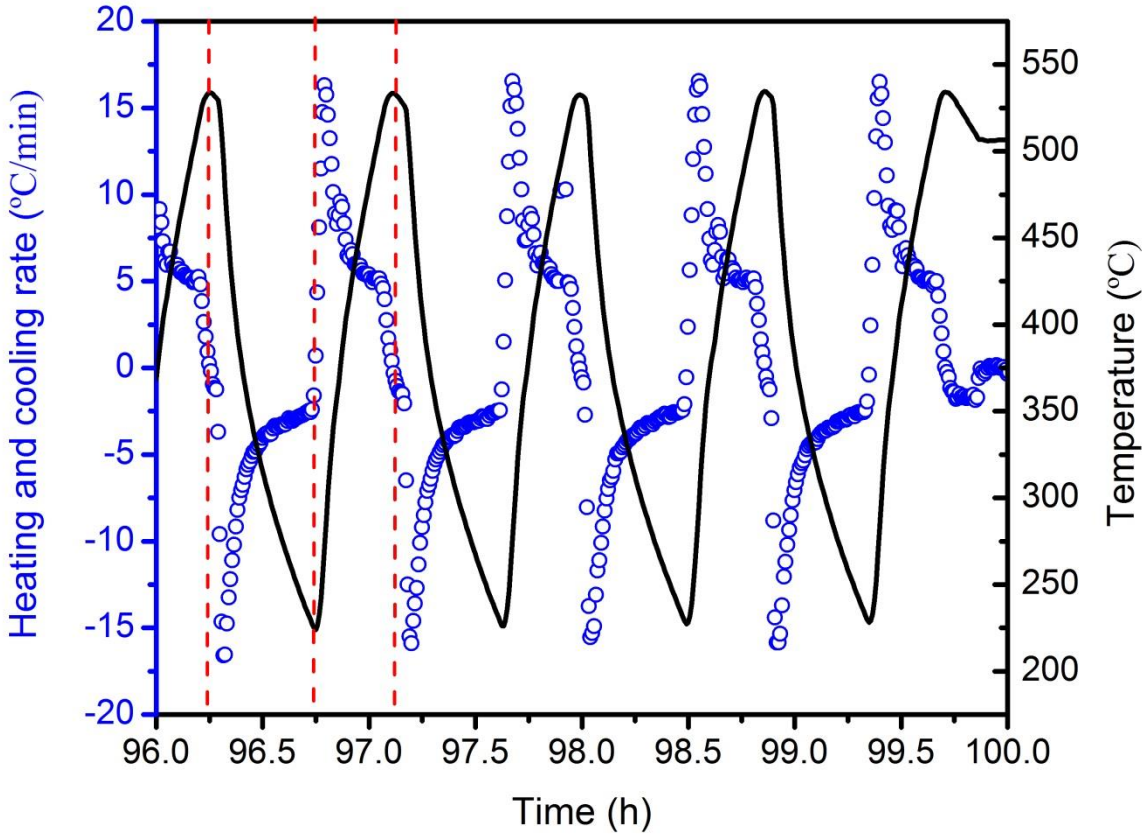


Figure S9 Amplified temperature profile and cooling/heating rate.

Table S1 Performance comparison for low temperature SOFCs

Cell composition	Measurement condition	Temperature	Peak power density (W/cm^2)	Ref.
GDC-based LT-SOFC with BCFZY0.1 cathode	H_2(50mL/min)|Air (150 mL/min)	500 °C	0.97	This work
GDC-based LT-SOFC with BCFZY0.1 cathode	H_2(50mL/min)|Air (150 mL/min)	450 °C	0.64	This work
GDC-based LT-SOFC with BCFZY0.1 cathode	H_2(50mL/min)|Air (150 mL/min)	400 °C	0.32	This work
GDC-based LT-SOFC with the core/shell-fibre-structured BSCF-GDC cathode	H_2(60mL/min)|Air (250 mL/min)	500 °C	1.58	[1]
GDC-based LT-SOFC with the core/shell-fibre-structured BSCF-GDC cathode	H_2(60mL/min)|Air (250 mL/min)	450 °C	0.84	[1]
GDC-based SOFC with PBSCF05-GDC composite cathode	H_2 with 3 v% H_2O (100 mL/min) |Ambient air	500 °C	0.67	[2]
SDC-based SOFC with SNC0 .95 cathode	H_2 (80 mL/min) |Ambient air	500 °C	1.02	[3]
SDC-based SOFC with SNC0 .95 cathode	H_2 (80 mL/min) |Ambient air	450 °C	0.66	[3]
SDC-based SOFC with SNC0 .95 cathode	H_2 (80 mL/min) |Ambient air	400 °C	0.37	[3]
GDC-based SOFC with LBSCF-40GDC composite cathode	H_2 (100 mL/min) | air	500 °C	0.65	[4]
GDC-based SOFC with $B_{0.9}$CFN cathode	H_2 (80 mL/min) |Ambient air	500 °C	0.42	[5]
GDC-based SOFC with LSCF nanostructured cathode	H_2|Oxygen	500 °C	0.297	[6]
GDC-based SOFC with LSCF nanostructured cathode	H_2|Oxygen	450 °C	0.131	[6]
GDC-based SOFC with PBSC hollow nano fiber cathode	H_2 with 3 v% H_2O |Ambient air	500 °C	0.62	[7]
GDC-based SOFC with PBSC hollow nano fiber cathode	H_2 with 3 v% H_2O |Ambient air	450 °C	0.36	[7]

Table S2 Long-term durability comparison for BCFZY0.1 cell and other SOFCs

Cell composition	Measurement condition	Temperature	Stability/degradation rate	Ref.
GDC-based LT-SOFC with BCFZY0.1 cathode	H_2(50mL/min)|Air (150 mL/min)	500 °C/400 °C	Current density=0.4A/cm^2 Current density=0.16 A/cm^2 Current density=0.3 A/cm^2 Total 2500 hours operation without degradation	This work
GDC-based LT-SOFC with the core/shell-fibre-structured BSCF-GDC cathode	H_2(60mL/min)|Air (250 mL/min)	550 °C	Current density=1 A/cm^2 Degradation rate=5.6% for 250 hours Current density=0.5 A/cm^2 Degradation rate=0.6% for 50 hours	1
SOFC with nanoparticulate LSM infiltrated cathode	H_2 with 3 v% H_2O |air	650 °C	Current density=0.15 A/cm^2 500 hours stable operation	8
YSZ-based SOFC with LSM-YSZ nano-composite	H_2 with 3 v% H_2O (200 mL/min)|Air (300 mL/min)	800 °C	Current density=1 A/cm^2 550 hours stable operation	9
GDC-based SOFC with PBSCF05-GDC composite cathode	H_2 with 3 v% H_2O (100 mL/min) |Ambient air	550 °C	Constant Voltage 0.6V 150 hours stable operation	2

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