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Supporting Information

Ce-doped $La_{0.7}Sr_{0.3}Fe_{0.9}Ni_{0.1}O_{3-\delta}$ as Symmetrical Electrode for High Performance Direct Hydrocarbon Solid Oxide Fuel Cell

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Table S1 Comparison of the cell performance for $LaFeO_{3-\delta}$ based-SSOFC symmetrical electrodes using H_2 as fuel.

electrode	electrolyte	thickness (μm)	temperature (ºC)	PPD (mW cm-2)	reference
$La_{0.7}Sr_{0.3}Fe_{0.9}Ni_{0.1}O_{3-\delta}$	LSGM	300	800	678	this work
			700	254	
$La_{0.6}Ce_{0.1}Sr_{0.3}Fe_{0.9}Ni_{0.1}O_{3-\delta}$	LSGM	300	800	653	
			700	303	
$La_{0.5}Sr_{0.5}Fe_{0.8}Cu_{0.2}O_{3-\delta}$	SSZ[a)]	230	800	577	1
$La_{0.6}Sr_{0.4}Fe_{0.8}Cu_{0.2}O_{3-\delta}$	LSGM	300	800	162	2
$La_{0.7}Sr_{0.3}Fe_{0.7}Ga_{0.3}O_{3-\delta}$	LSGM	300	800	489	3
$La_{0.6}Sr_{0.4}Fe_{0.9}Sc_{0.1}O_{3-\delta}$ infiltrated LSGM	LSGM	18	800	560	4
$La_{0.6}Ca_{0.4}Fe_{0.8}Ni_{0.2}O_{3-\delta}$ infiltrated SDC	SDC	300	800	510	5
$La_{0.4}Sr_{0.6}Co_{0.2}Fe_{0.7}Nb_{0.1}O_{3-\delta}$	LSGM	300	800	380	6

SSZ[a)]: Sc and Ce doped ZrO_2 10Sc1CeSZ

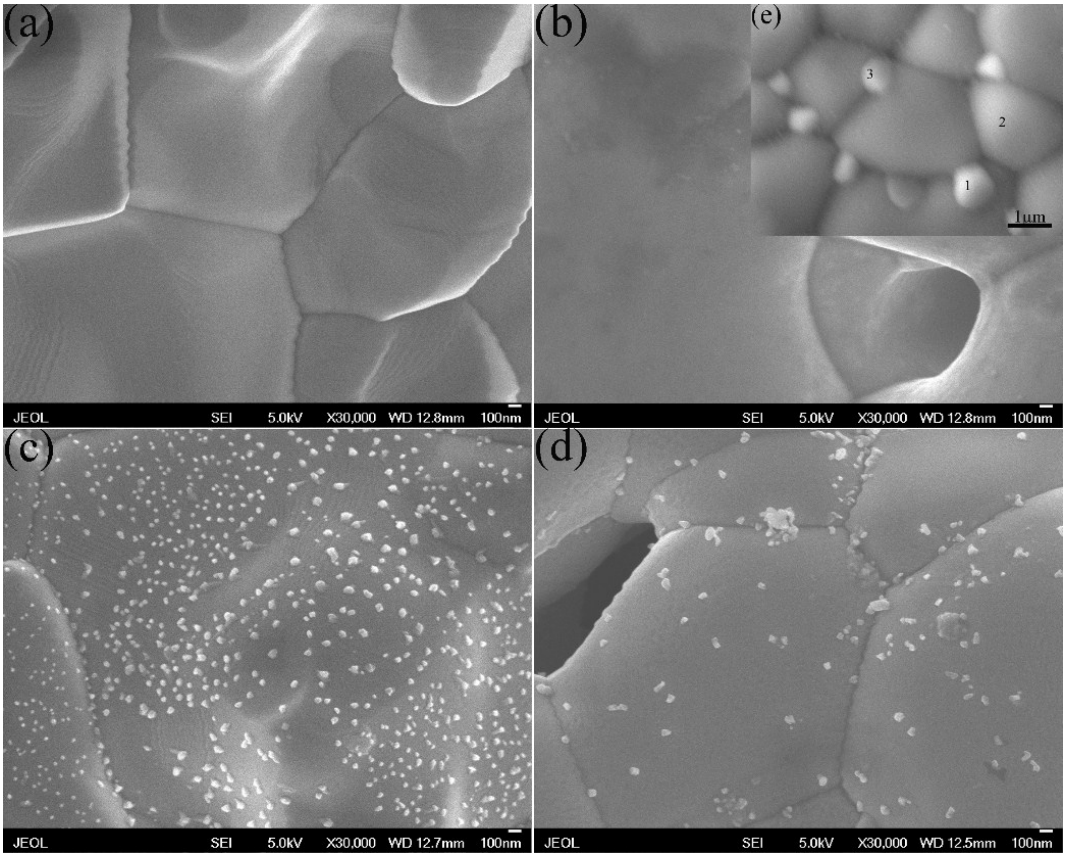

Fig. S1 SEM images of (a, b) as-synthesized LSFNi and CLSFNi; (c, d) reduced LSFNi and CLSFNi under 10% H_2 atmosphere at 800 °C for 10 h; (e) SEM image of CLSFNi at low magnification.

Table S2 the EDS results of as-synthesised CLSFNi in Fig. S1.

Elements	O	Fe	Ni	Sr	La	Ce
Point 1 (atomic %)	69.84	7.23	0.66	3.80	5.17	13.29
Point 2 (atomic %)	65.05	16.27	1.21	7.00	8.64	1.83
Point 3 (atomic %)	71.58	9.38	0.52	4.56	5.66	8.30

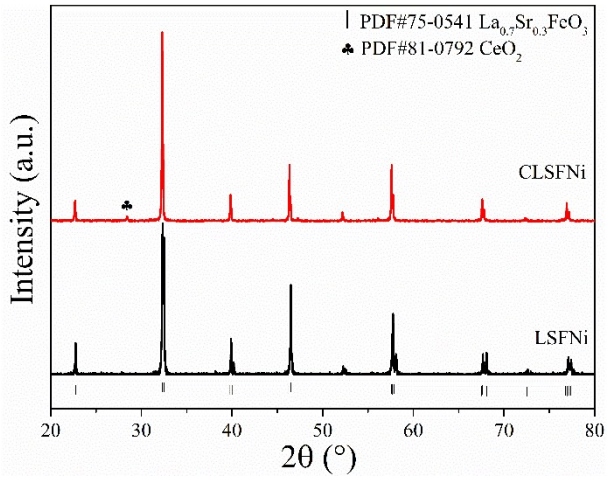

Fig. S2 Post-mortem XRD patterns of samples after electrical conductivity measurement.

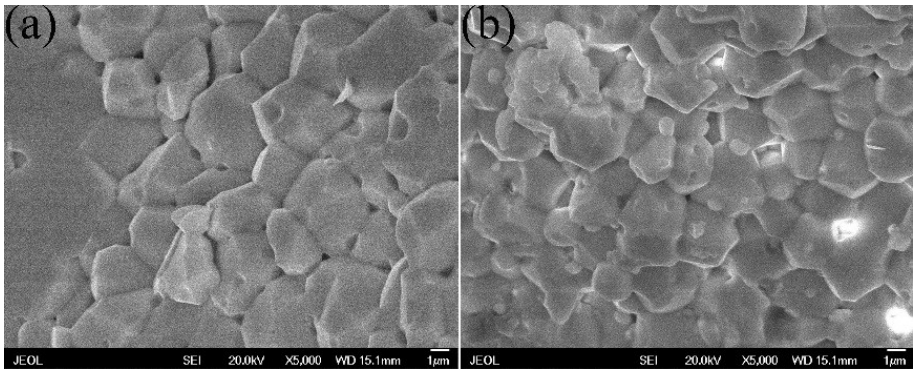

Fig. S3 Post-mortem cross-section microstructure of samples after electrical conductivity measurement. (a) LSFNi; (b) CLSFNi.

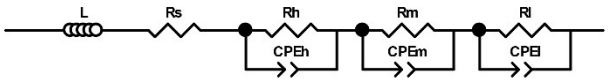

Fig. S4 Equivalent circuit used to fit to the EIS data.

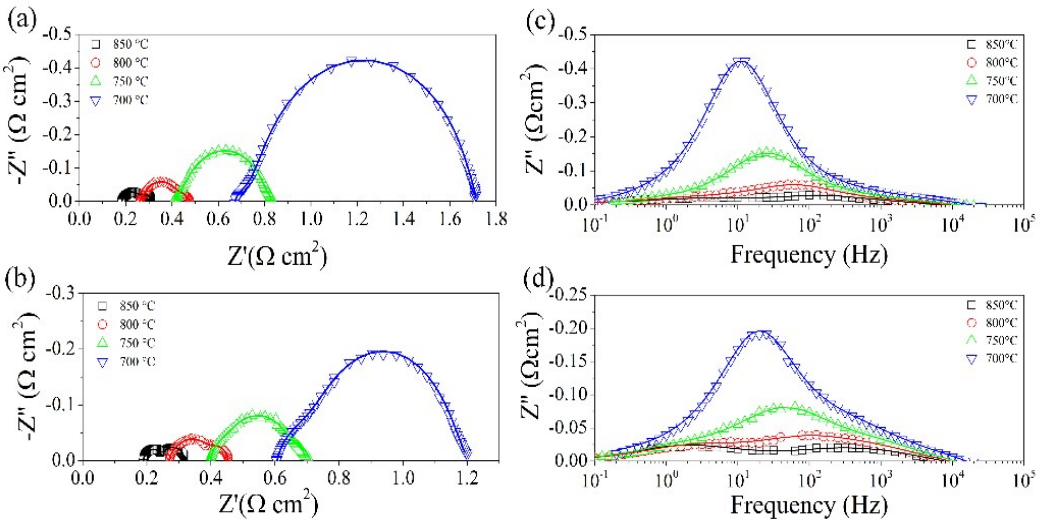

Fig. S5 Fitting results of EIS for H_2-fueled symmetrical cells.(a, c) LSFNi electrode; (b, d) CLSFNi electrode.

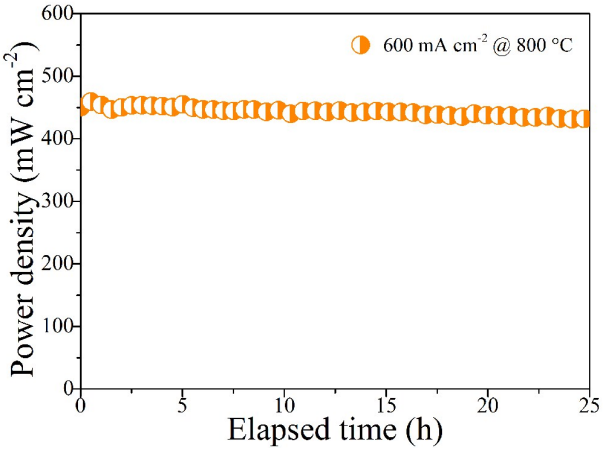

Fig. S6 Stability of the LSFNi symmetrical cell with H_2 (3% H_2O) under a constant current density of 600 mA cm^{-2} at 800 ℃.

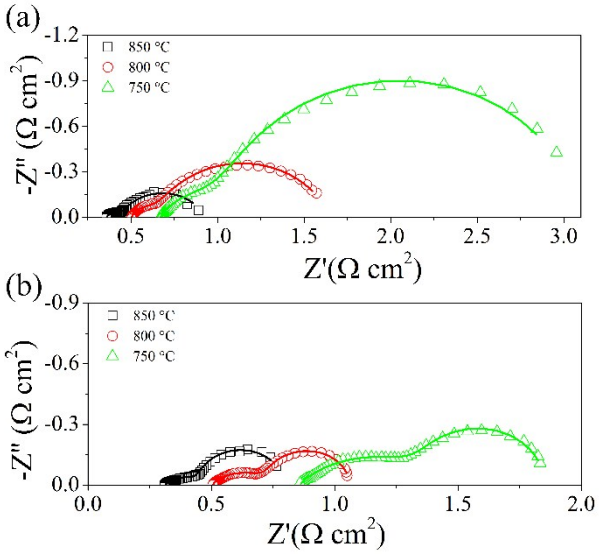

Fig. S7 Fitting results of EIS for CH_4-fueled symmetrical cells.(a) LSFNi electrode; (b) CLSFNi electrode.

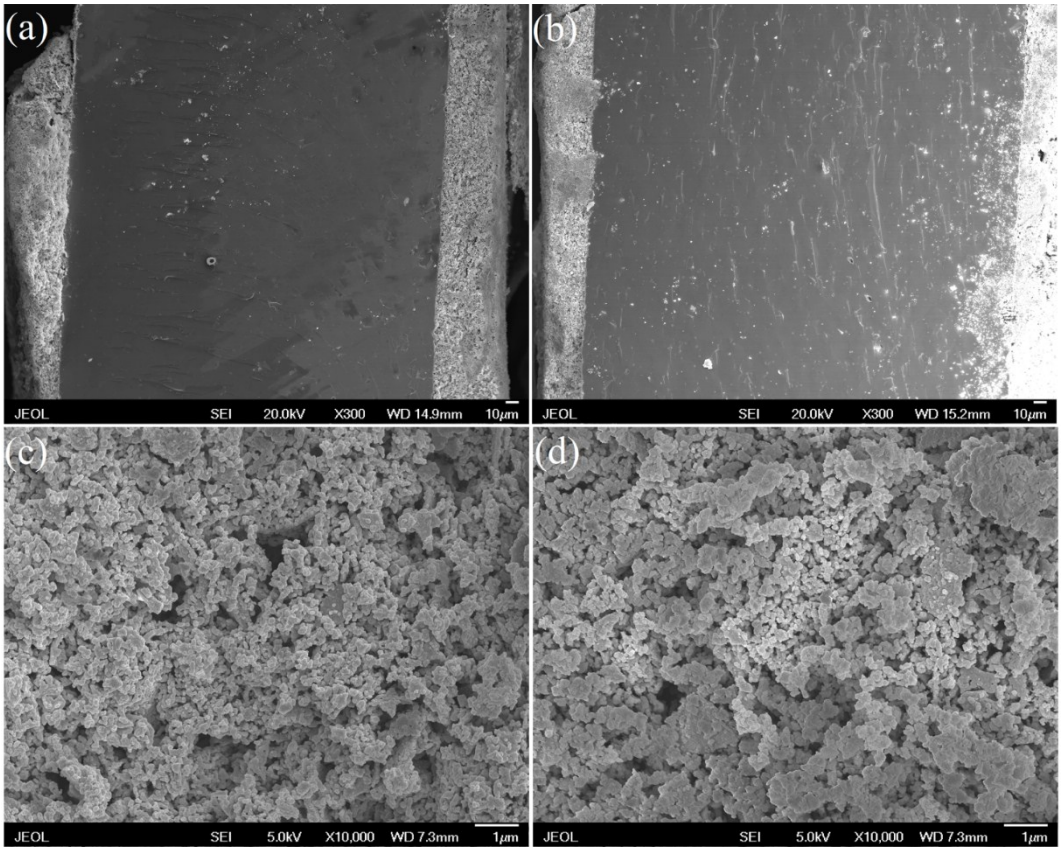

Fig. S8 Microstructure and cross section of symmetrical cells. (a) LSFNi/LSGM/LSFNi after stability testing with H_2 as fuel; (b) CLSFNi/LSGM/CLSFNi after stability testing with CH_4 as fuel; (c) cathode section of (b); (d) anode section of (b).

References for supplementary information:

[1]. J. Lu, Y. M. Yin, J. C. Li, L. Xu, Z. F. Ma, *Electrochem. Commun.* 2015, **61**, 18-21.

[2]. F. Zurlo, I. N. Sora, V. Felice, I. Luisetto, C. D'Ottavi, S. Licoccia, E. Di Bartolomeo, *Acta Mater.* 2016, **112**, 77-83.

[3]. Z. B. Yang, Y. Chen, C. L. Jin, G. L. Xiao, M. F. Han, F. L. Chen, *RSC Advances* 2015, **5**, 2702-2705.

[4]. X. Liu, D. Han, Y. Zhou, X. Meng, H. Wu, J. Li, F. Zeng, Z. Zhan, *J. Power Sources* 2014, **246**, 457-463.

[5]. G. M. Yang, C. Su, Y. B. Chen, M. O. Tade, Z. P. Shao, *J. Mater. Chem. A* 2014, **2**, 19526-19535.

[6]. Z. Yang, N. Xu, M. Han, F. Chen, *Int. J. Hydrogen Energy* 2014, **39**, 7402-7406.