Electronic Supplementary Material (ESI) for Nanoscale Advances.

A New Strategy for Improving the Electrochemical Performance of Perovskite Cathode: Pre-calcining the Perovskite Oxide Precursor in Nitrogen Atmosphere

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Table S1 Structural parameters calculated by XRD Spectrum

sample	SSC-400	SSC-600	SSC-800	SSC-air
a(Å)	5.406	5.413	5.408	5.407
b(Å)	7.551	7.539	7.612	7.508
c(Å)	5.324	5.348	5.342	5.364
V(nm^3)	216.48	217.96	219.96	217.80

Table S2 Oxygen non-stoichiometry of SSC powders at room temperature

Atmosphere,T/℃	n_0	δ_0
Untread	2.90	0.10
N_2, 400℃	2.90	0.10
N_2, 600℃	2.89	0.11

N_2, 800℃	2.88	0.12

Table S3 The result parameters calculated by XPS fitting Spectrum of Co 2p

Conditions	Co^{3+}		Co^{4+}		Oxygen nonstoichiometry
	B.E/eV	Proportion %	B.E/eV	Proportion %	
Untreated	780.1-795.1	83.56	782.3-797.1	16.44	2.8996
N_2,400℃	780.0-795.1	73.67	782.2-797.1	26.33	2.9006
N_2,600℃	780.0-795.1	62.88	781.75-797.1	37.12	2.8877
N_2,800℃	780.2-795.2	61.29	782.1-797.1	38.7	2.8747

Table S4 The result parameters calculated by XPS fitting Spectrum of O 1s

Conditions	Lattice oxygen		Adsorbed oxygen	
	B.E/eV	Proportion%	B.E/eV	Proportion%
Untreated	528.4	35.71	530.9	64.29
N2,400℃	528.4	33.36	530.9	66.64
N2,600℃	528.4	33.16	530.9	66.84
N2,800℃	528.8	33.05	531.1	66.95

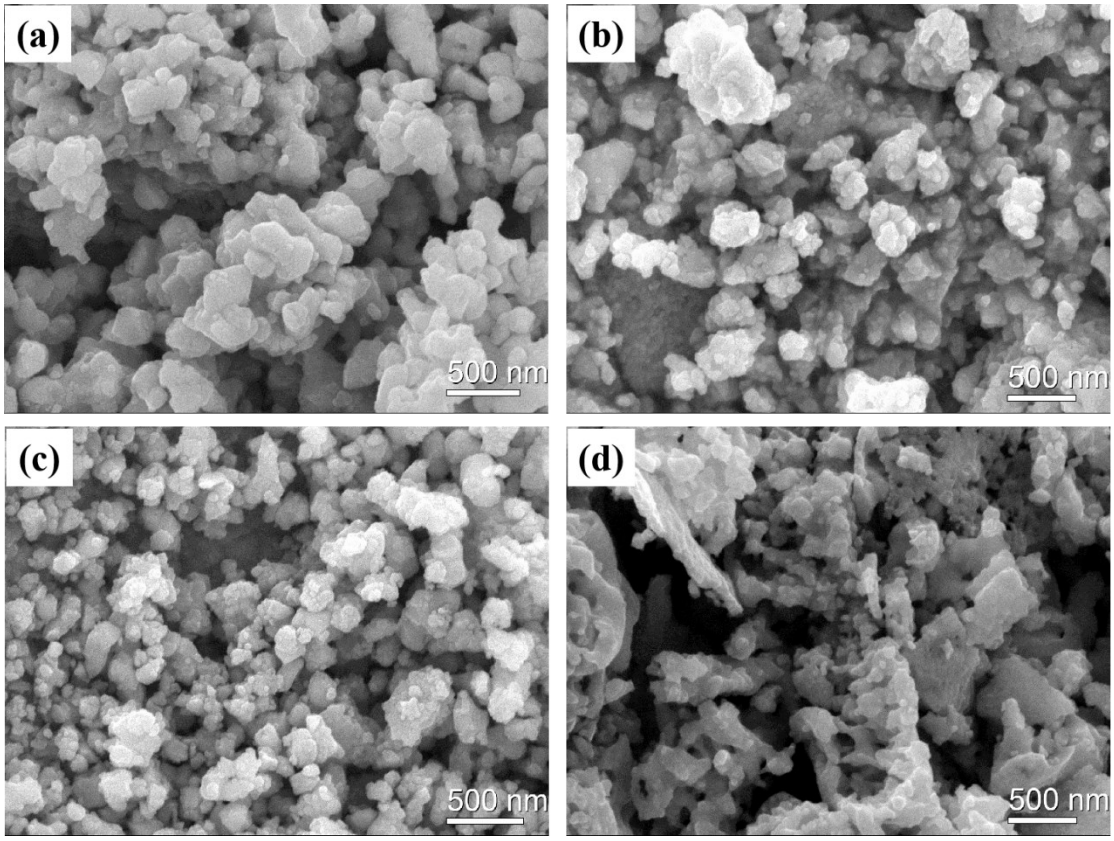

Fig. S1 SEM images of SSC powders: (a) SSC-400; (b) SSC-600; (c) SSC-800; (d) SSC-air, untreated.

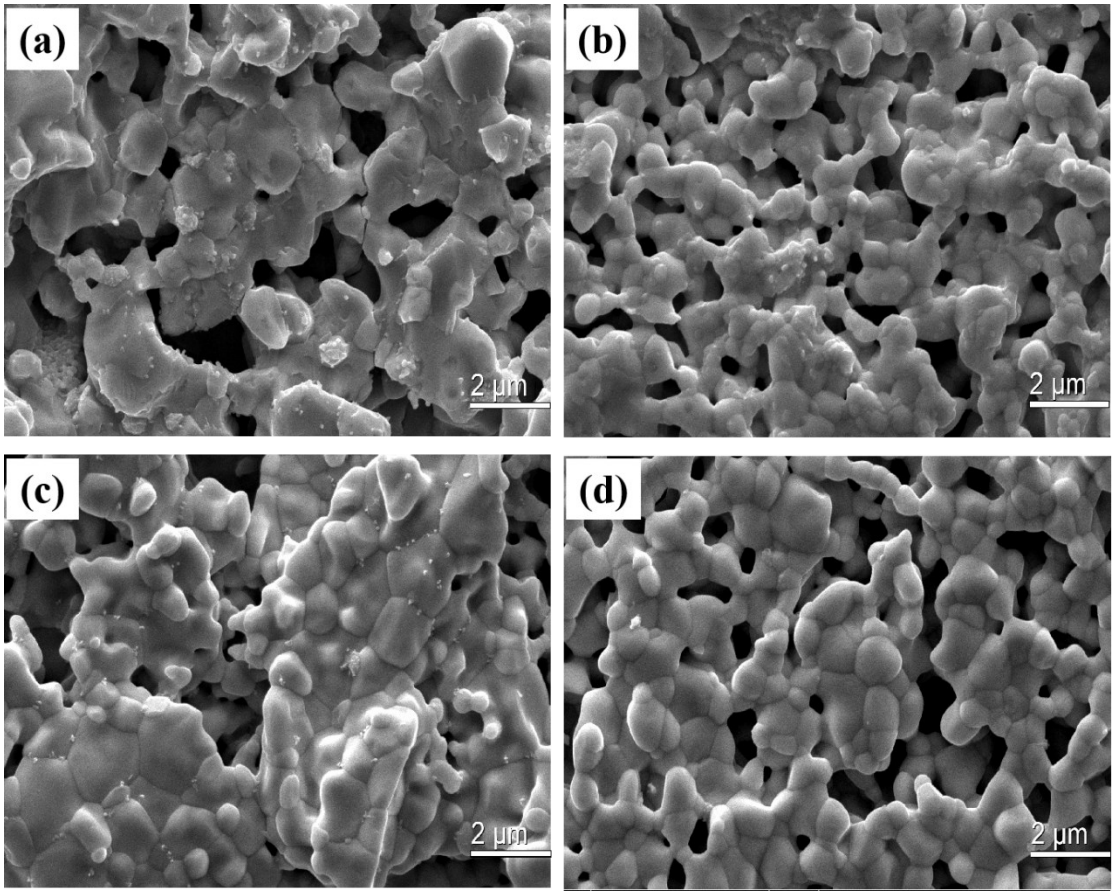

Fig. S2 Surface section SEM images of SSC cathodes prepared at 1050 ºC, (a) SSC-400; (b) SSC-600; (c) SSC-800; (d) SSC-air.

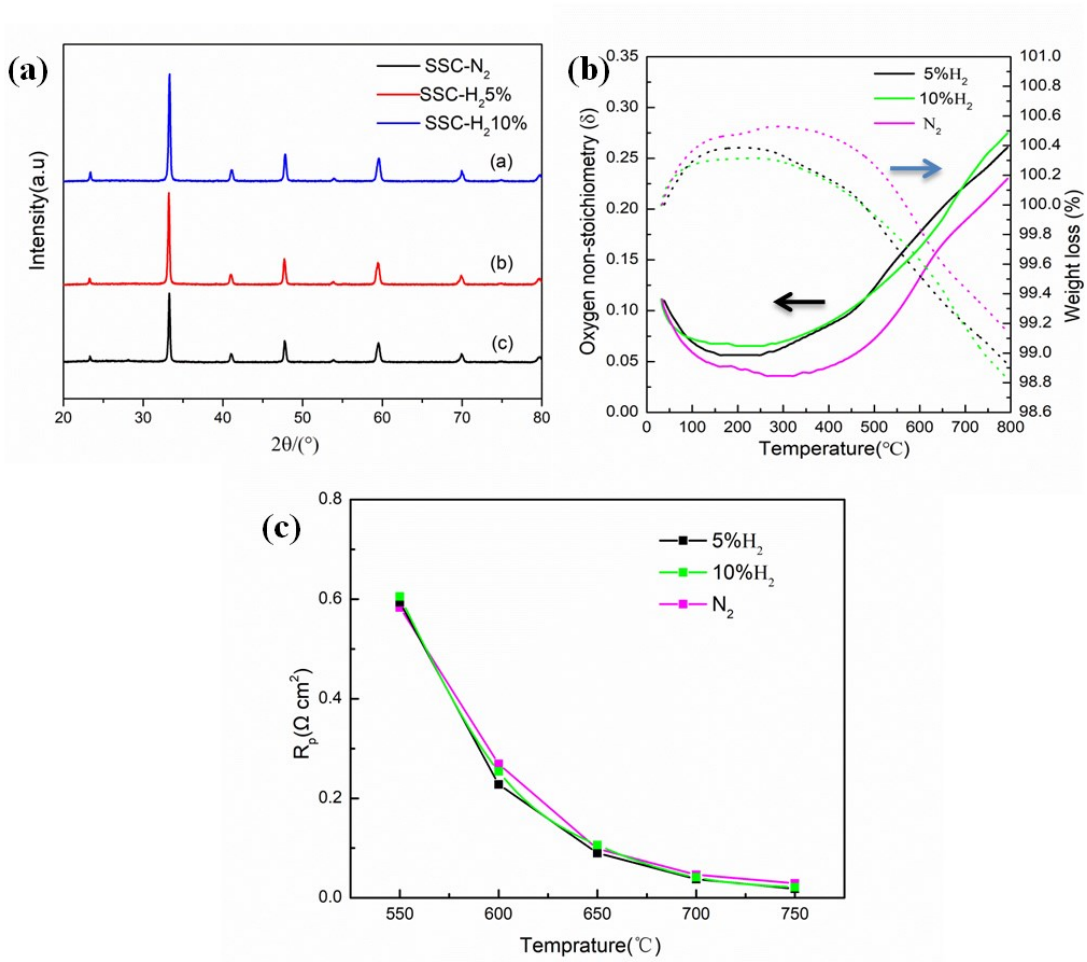

Fig. S3 (a) XRD image of the SSC powders which precursor sintered at 600 ºC for 2 h in 0%, 5% and 10% H_2/N_2. (b) Oxygen non-stoichiometry and TG plots of the SSC annealed under different condition. TG was measured in air. (c) The R_p values of the cathodes.

Firstly, the precursors were pre-calcined at 600 ºC in different concentration of hydrogen (0%, 5%, 10% H_2/N_2), and then the powders were recalcined in air for 2 h at 900 ºC. Fig. S3a shows the XRD image of the SSC powders. There was no impurity phase formed, which proves that the reduction atmosphere pretreatment (5%, 10% H_2/N_2) will not have a significant effect on the crystal structure of the sample. Fig. S3b shows the experimental results of δ and thermogravimetry of SSC tested in air atmosphere. The δ values are 0.23, 0.26 and 0.27 for 0%, 10% and 5% H_2/N_2 at 800 ºC, respectively. The oxygen vacancies of the samples pretreated with hydrogen (5%, 10% H_2/N_2) are slightly higher than those of the samples pretreated with pure nitrogen atmosphere which tested in air atmosphere. The sample in a hydrogen

atmosphere (5%, 10% H_2/N_2) treatment increased the oxygen vacancy of the sample. Because hydrogen is a reducing gas, it can also carbonize organic compounds in hydrogen atmosphere during the pre-sintering process. At the same time, hydrogen may reduce the metal ions, thus increasing the oxygen vacancies in the samples. Fig. S3c shows the R_p of the cathodes. The polarization resistance of 5% and 10% H_2/N_2 pretreated samples is slightly higher than that of nitrogen pretreated samples at 600-650 ºC. At 700-750 ºC, the polarization resistance of the three samples was almost the same. The results showed that the samples treated with 5% and 10% H_2/N_2 have similar oxygen vacancies and catalytic performance as those treated with pure N_2.