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Supplementary Information

Enhanced Catalytic Activity and Stability of SOFC Electrodes through Plasma-driven Surface Modification

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Table S1 The area intensity and ratio for X-ray photoelectron spectroscopy (XPS) spectra of Sr $3d_{5/2}$ and $3d_{3/2}$.

Sample	Intensity		Area ratio	Intensity		Area ratio
	$Sr_{(lattice)}$ $3d_{5/2}$	$Sr_{(lattice)}$ $3d_{3/2}$		$Sr_{(non\text{-}lattice)}$ $3d_{5/2}$	$Sr_{(non\text{-}lattice)}$ $3d_{3/2}$	
Bare	25864.4	17241.2	3:2	31040	20691.2	3:2
Plasma	25966.6	17309.3	3:2	18715.1	12475.5	3:2

Table S2 The deconvolution analysis areas for each peak.

Sample	$O_{lattice}$		O_{defect}		$O_{surface}$		H_2O_{ad}		Area ratio		
	BE	FWHM	BE	FWHM	BE	FWHM	BE	FWHM	$O_{lattice}$	O_{defect}	$O_{defect}/O_{lattice}$
Bare	528.56	1.10	529.4	2.08	531.35	1.74	533.3	1.96	72683.8	55923.6	0.77
Plasma	528.23	1.16	529.4	1.90	531.46	1.83	533.3	1.94	42516.9	47572.9	1.12

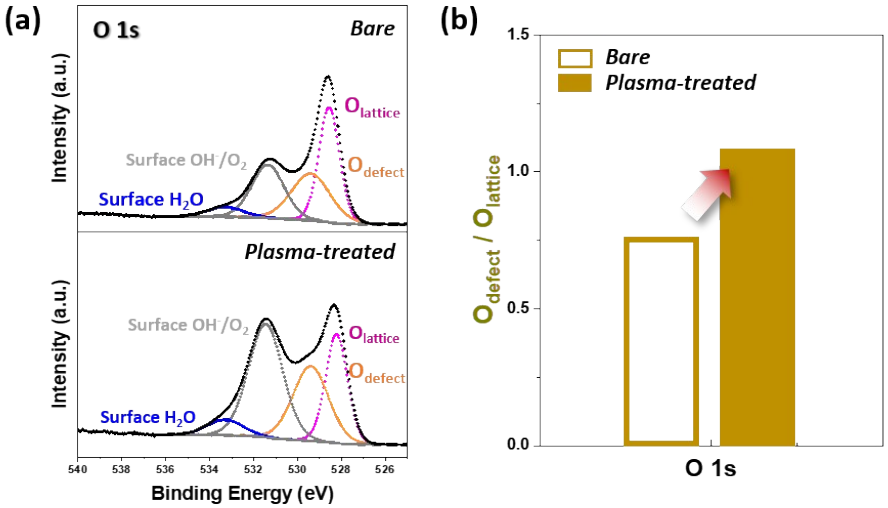


Fig. S1 X-ray photoelectron spectroscopy (XPS) results of (a) O 1s spectra, and (b) summarized graph of bare and plasma-treated $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF) surfaces.

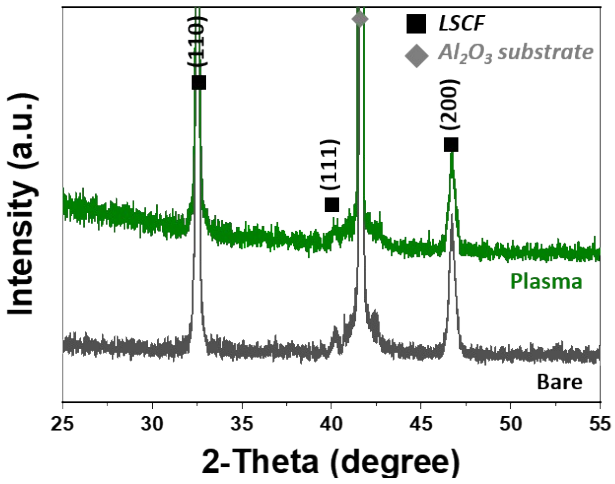


Fig. S2 X-ray diffraction (XRD) patterns of $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF) films with plasma exposure.

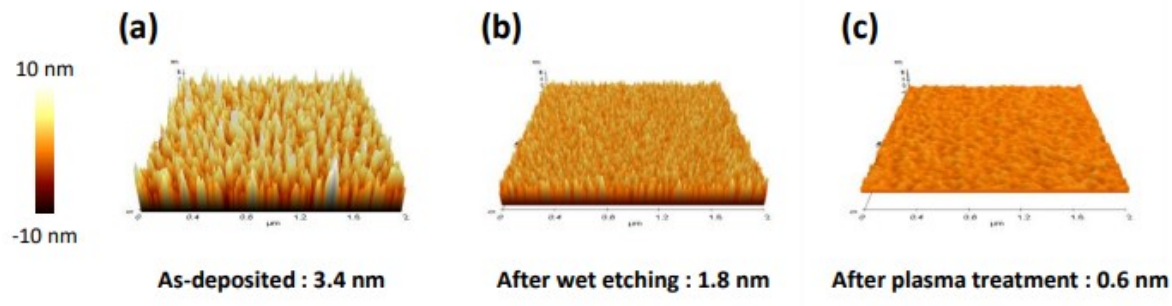
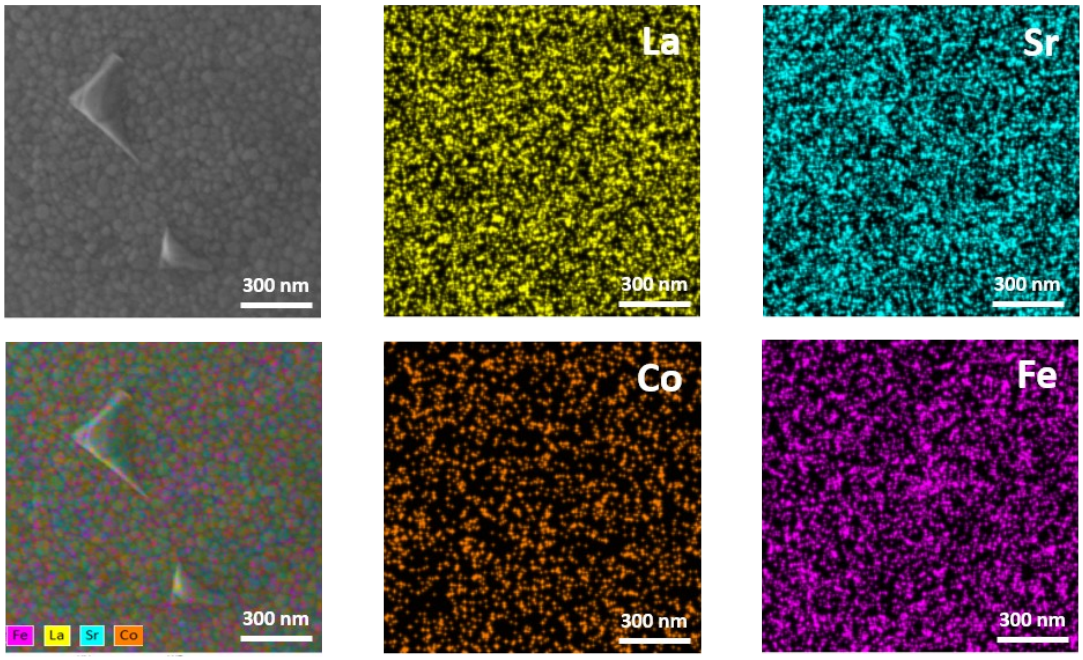
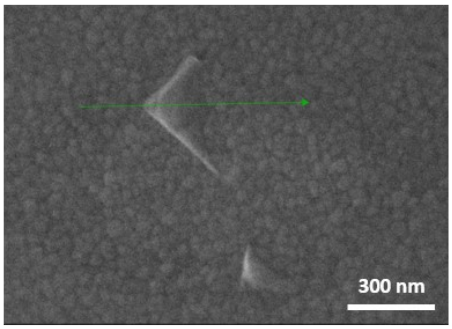


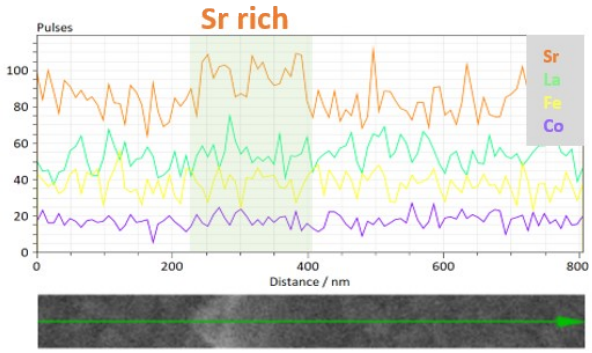
Fig. S3 Surface morphological changes of (a) as-deposited, (b) bare, and (c) plasma-treated $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF) films by atomic force microscopy (AFM).

(a)

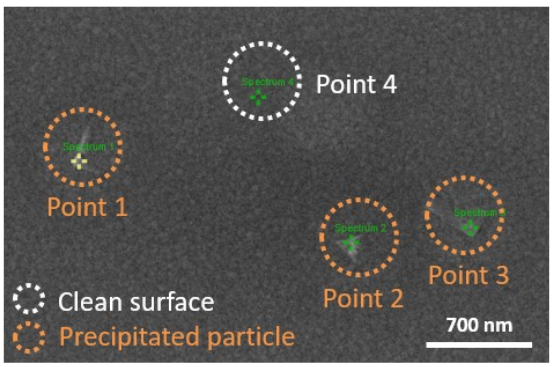

La
Sr
Co
Fe
300 nm
Fe
La
Sr
Co

(b)


300 nm


Sr rich
Pulses
100
80
60
40
20
0
0
200
400
600
800
Distance / nm
Sr
La
Fe
Co

(c)


Point 4
Point 1
Point 2
Point 3
Clean surface
Precipitated particle
700 nm

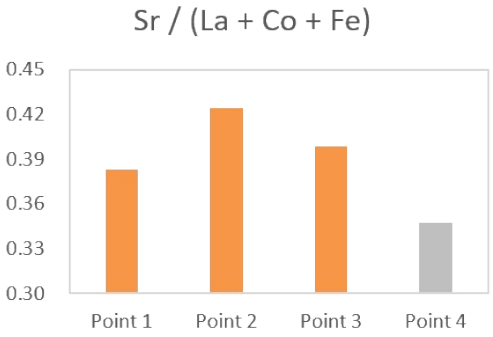

Sr / (La + Co + Fe)
0.45
0.42
0.39
0.36
0.33
0.30
Point 1
Point 2
Point 3
Point 4

Fig. S4 Scanning electron microscopy (SEM) analysis of bare $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF) thin films after heat treatment at 650 °C for 30 hours (a) energy-dispersive X-ray spectroscopy (EDS) elemental maps, (b) EDS line-scanning, and (c) EDS point analysis.

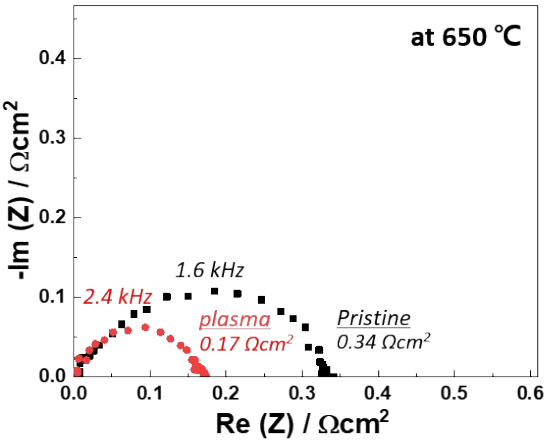


Fig. S5 Nyquist plots of pristine and plasma-treated $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF) at 650 ℃.

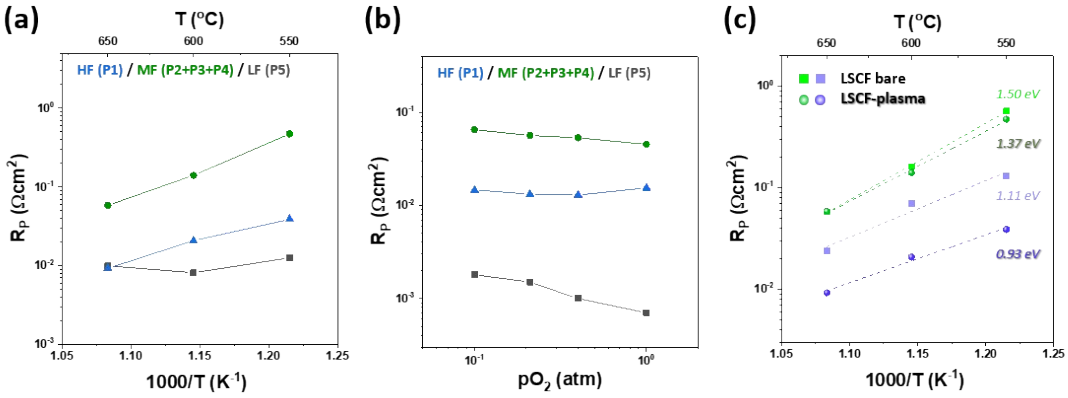


Fig. S6 (a) Temperature and (b) oxygen partial pressure dependencies results of plasma treated LSCF in different frequency region and (c) comparison of activation energy of medium frequency (MF) and high frequency (HF) resistance for bare and plasma-treated $La_{0.6}Sr_{0.4}Co_{0.2}Fe_{0.8}O_{3-\delta}$ (LSCF).

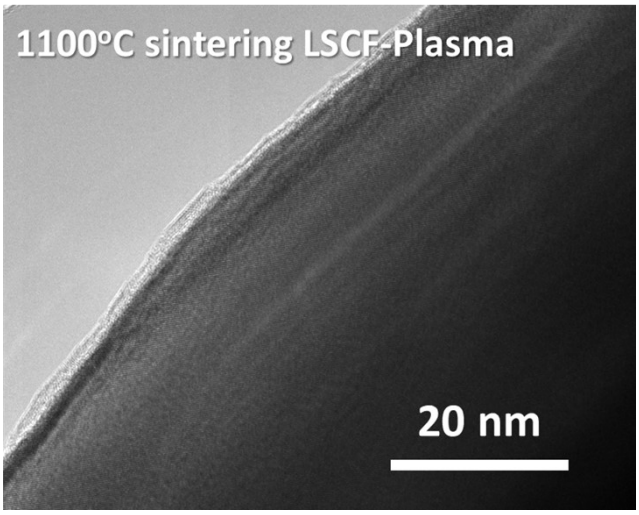


Fig. S7. HR-TEM image of 1100°C-sintered LSCF with plasma treatment