Electronic Supplementary Material (ESI) for Journal of Materials Chemistry A.

Supplementary Information for

Effect of Anode Functional Layer on Electrochemical Performances of $BaZr_xCe_{0.8-x}Y_{0.1}Yb_{0.1}O_{3-\delta}$ Protonic Solid Oxide Electrolysis Cells

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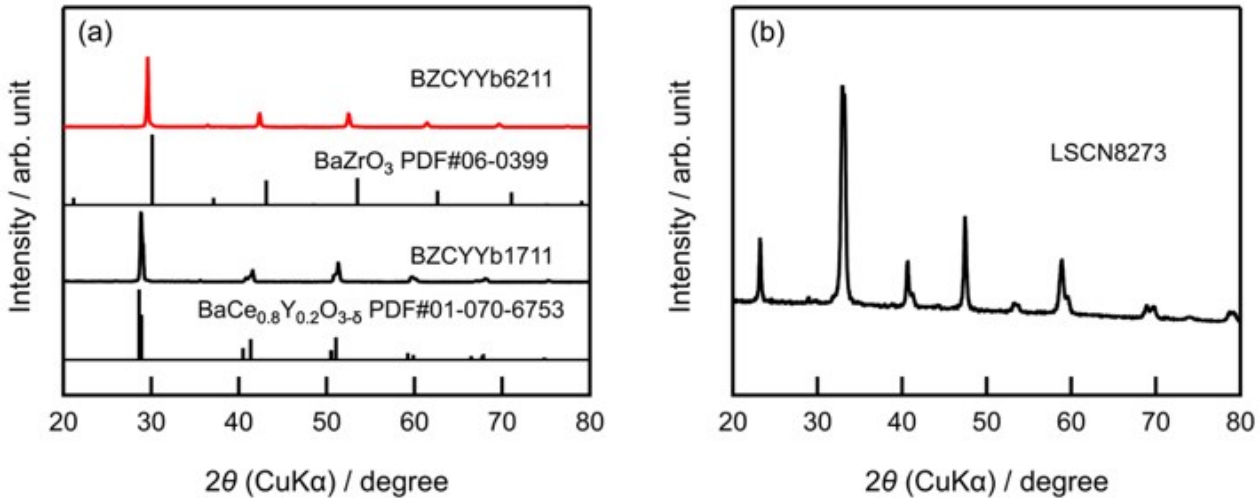

Fig. S1. XRD patterns of (a) BZCYYb1711 and BZCYYb6211 electrolyte powders, and (b) LSCN8273 anode powders.

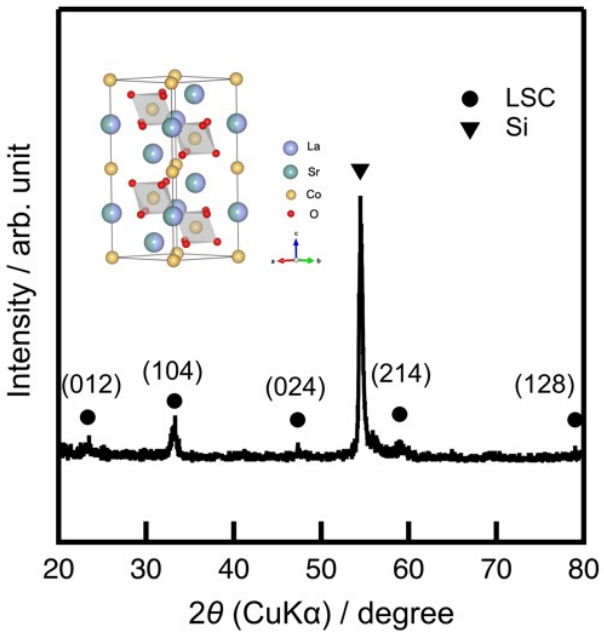

Fig. S2. XRD pattern of LSC thin film deposited on a silicon wafer.

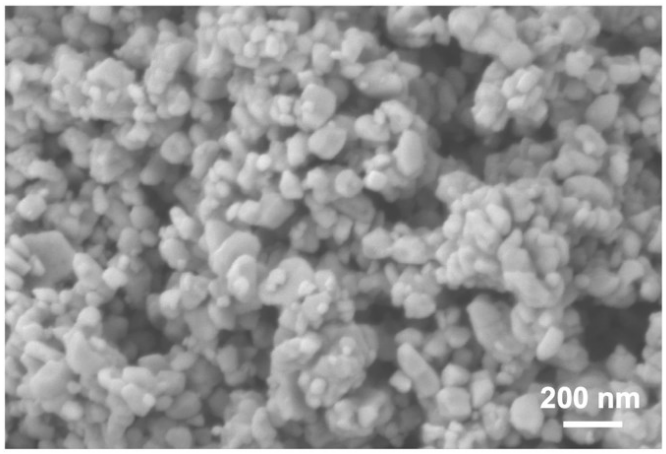

Fig. S3. SEM image of LSCN8273 powders.

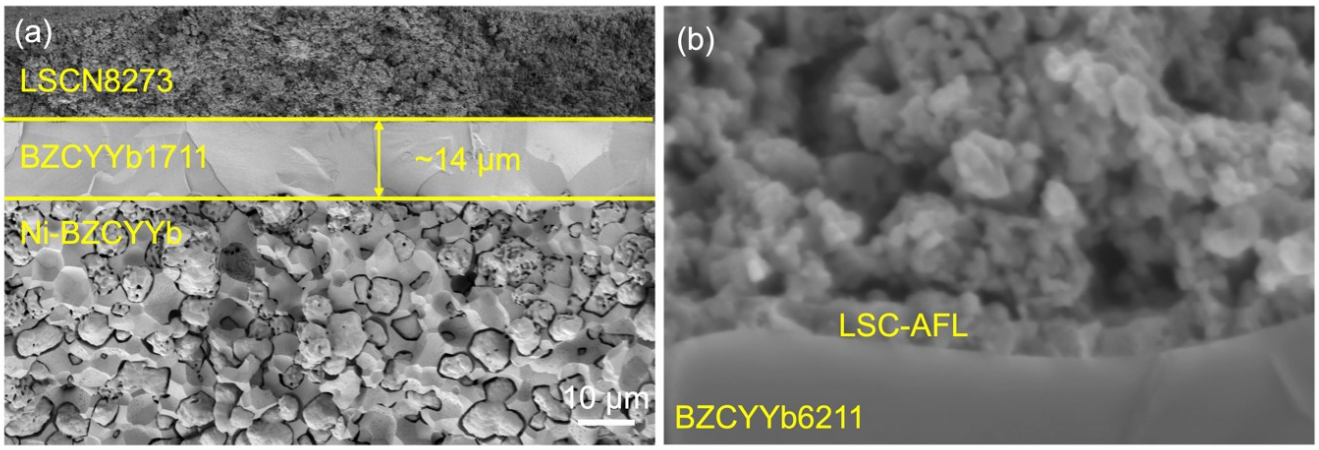

Fig. S4. (a) Cross-section SEM image of cathode-supported P-SOECs of BZCYYb1711 electrolyte.(b) Expand view of LSCN8273 anode and BZCYYb6211 electrolyte.

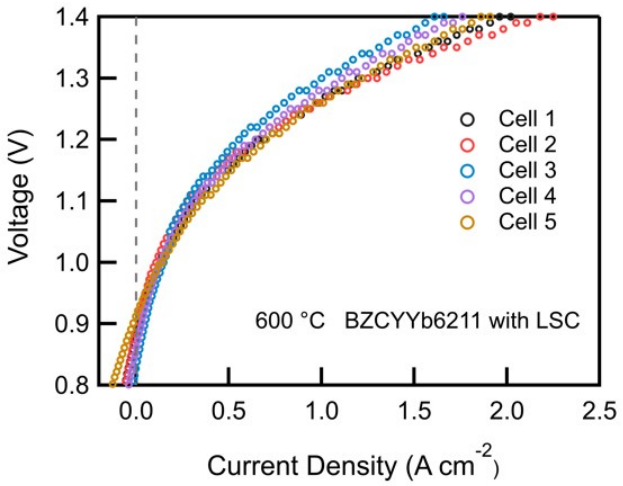

Fig. S5. *I-V* curves for five samples of BZCYYb6211 base electrolysis cells with LSC-AFL at 600

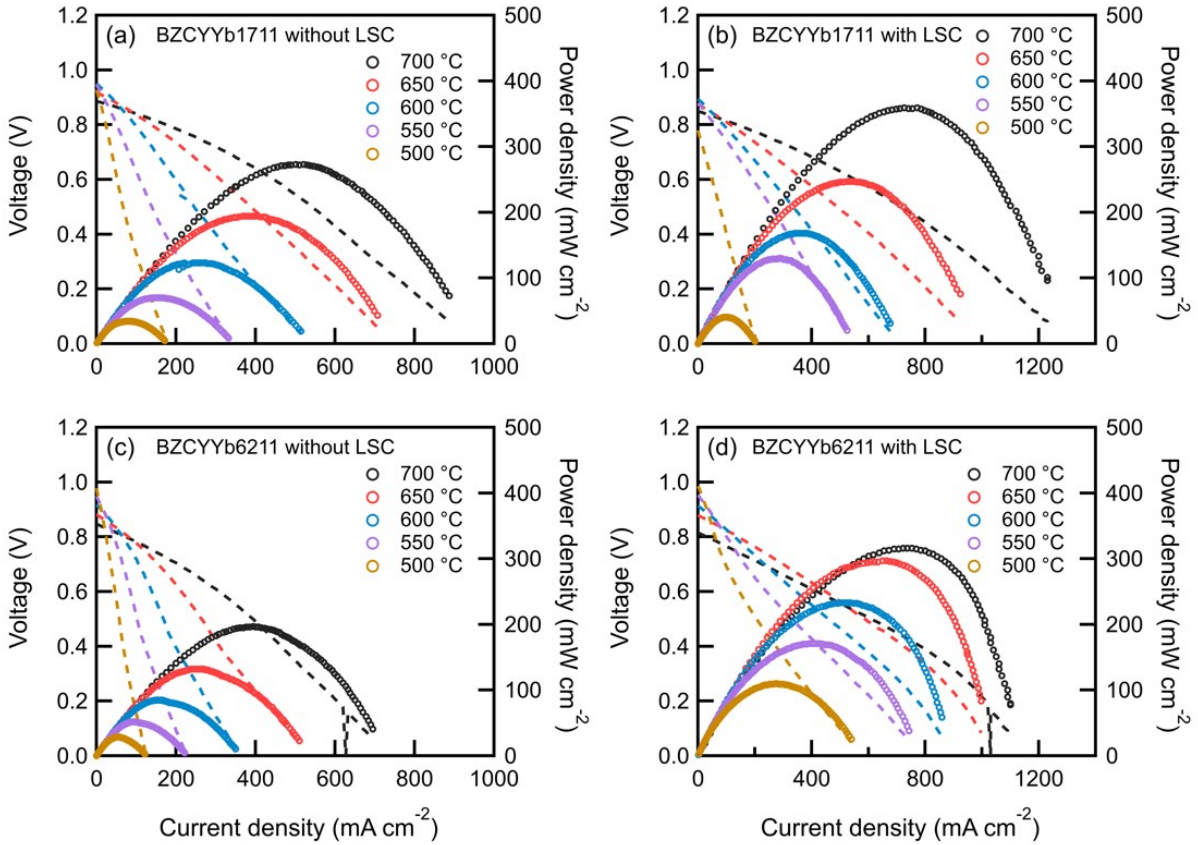

Fig. S6. Current-voltage-power (*I-V-P*) curves of fuel cell mode for the BZCYYb1711 base cells ((a) and (b)) and the BZCYYb6211 base ones ((c) and (d)) performed with 30%–H_2O/Air and humidified 10%–H_2/Ar gases to the air and fuel electrodes, respectively. (a) and (c) are the cells without LSC-AFL, and (c) and (d) ones with LSC-AFL.

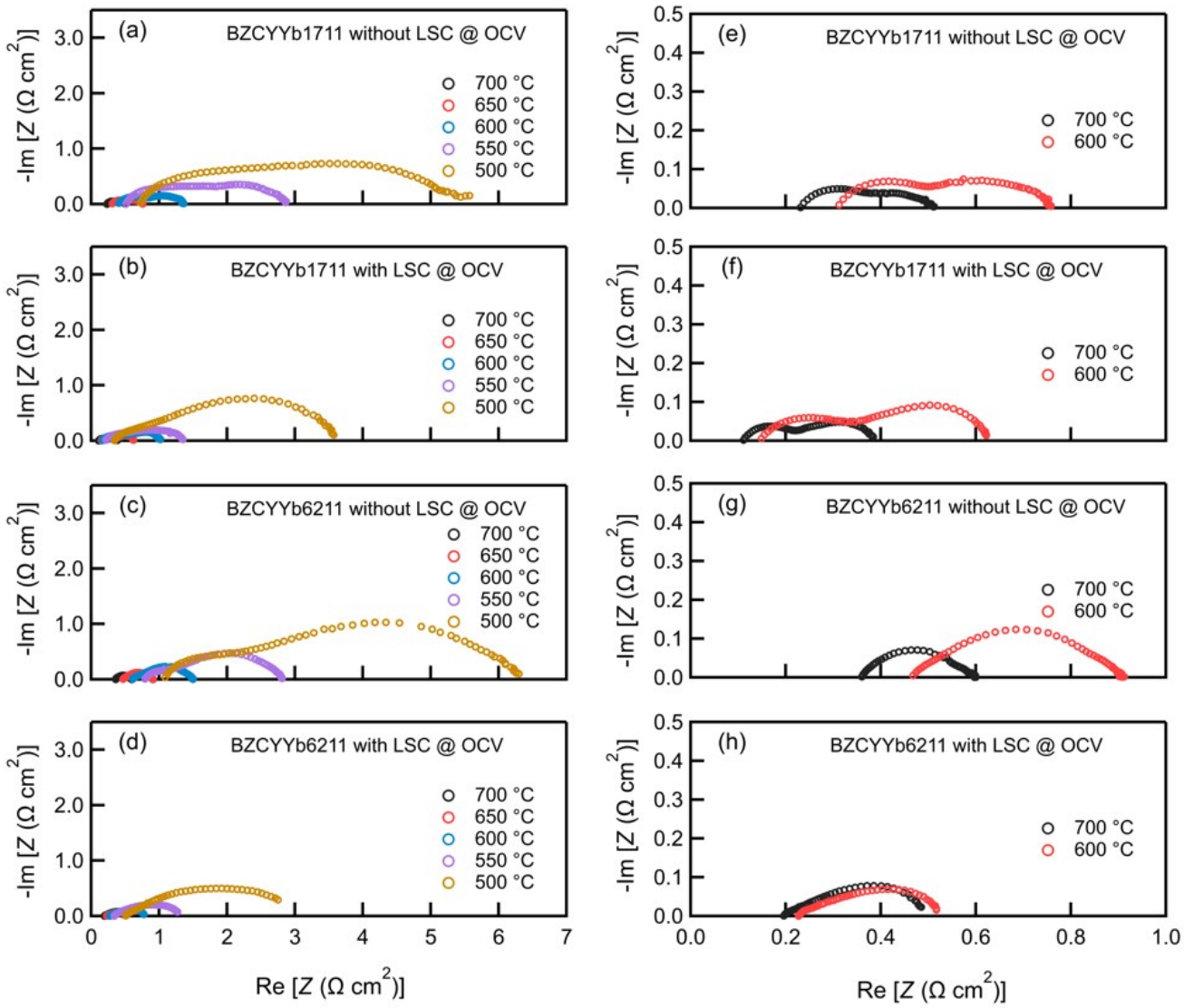

Fig. S7. EIS for BZCYYb1711 ((a) and (b)) and BZCYYb6211 ((c) and (d)) cells without and with LSC-AFL at various temperatures under OCV.

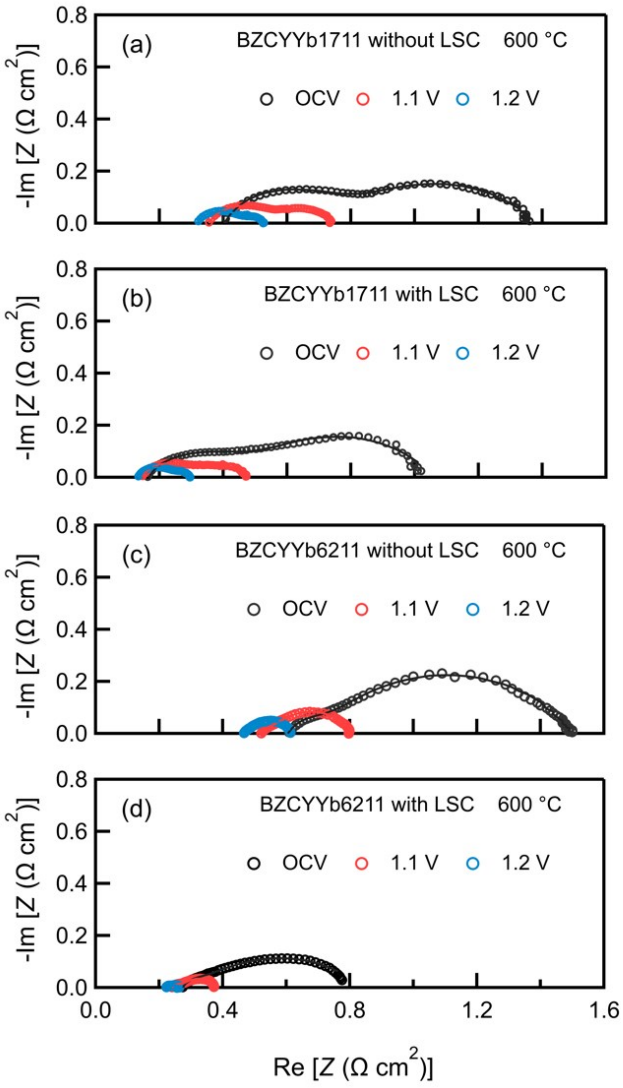

Fig. S8. EIS of BZCYYb1711 cells (e) without and (f) with LSC layer under various cell voltages at 600 ℃.

Table S1 Parameters of equivalent-circuit fitting analysis for impedance spectra of BZCYYb1711 and BZCYYb6211 cells without and with LSC anode functional layer.

P-SOECs	T (℃)	R_o (Ω cm^2)	S_{HF} arc			S_{LF} arc		
			R_{HF} (Ω cm^2)	f_{HF} (Hz)	E_a (eV)	R_{LF} (Ω cm^2)	f_{LF} (Hz)	E_a (eV)
BZCYYb1711 without LSC	600 ℃	0.30	0.52	1.14×10^4	0.70	0.56	2.23×10^1	1.04
	500 ℃	0.61	1.29	4.38×10^3		3.66	2.82×10^1	
BZCYYb6211 without LSC	600 ℃	0.52	0.21	3.50×10^4	1.15	0.77	1.12×10^2	0.95
	500 ℃	0.83	1.72	6.94×10^3		4.58	2.78×10^1	
BZCYYb6211 without LSC (LSC as anode)	600 ℃	0.49	0.10	4.98×10^4	-	0.71	1.10×10^2	-
	500 ℃	0.86	0.88	5.52×10^4		8.59	2.12×10^1	
BZCYYb1711 with LSC	600 ℃	0.12	0.40	1.28×10^3	0.44	0.54	3.35	0.88
	500 ℃	0.29	0.58	2.30×10^3		2.87	7.95	
BZCYYb6211 with LSC	600 ℃	0.26	0.06	8.46×10^2	0.09	0.51	3.44	0.79
	500 ℃	0.47	0.07	7.76×10^3		2.69	1.82	

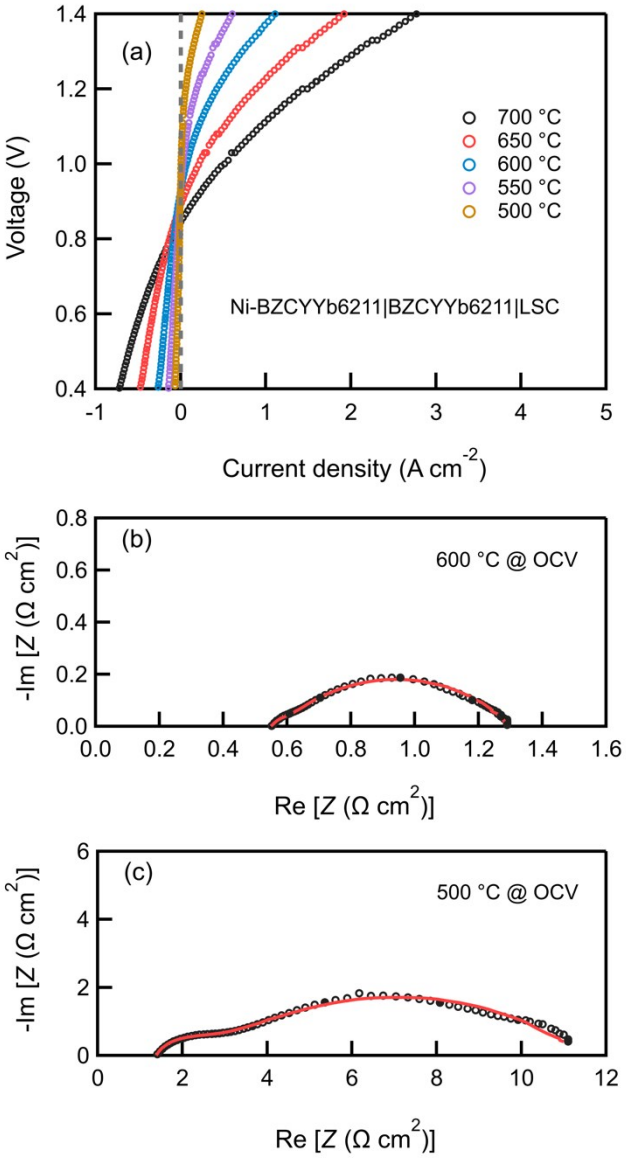

Fig. S9 (a) *I-V* curves of BZCYYb6211 cell using a $La_{0.5}Sr_{0.5}CoO_{3-\delta}$ (LSC) anode without AFL. The corresponding EIS at (b) 600 ℃ and (c) 500 ℃ under OCV condition.