Supplementary Materials

Chromium Deposition and Poisoning of Proton Conducting $BaZr_{0.1}Ce_{0.7}Y_{0.1}Yb_{0.1}O_{3-\delta}$ Electrolyte of Protonic Ceramic Cells

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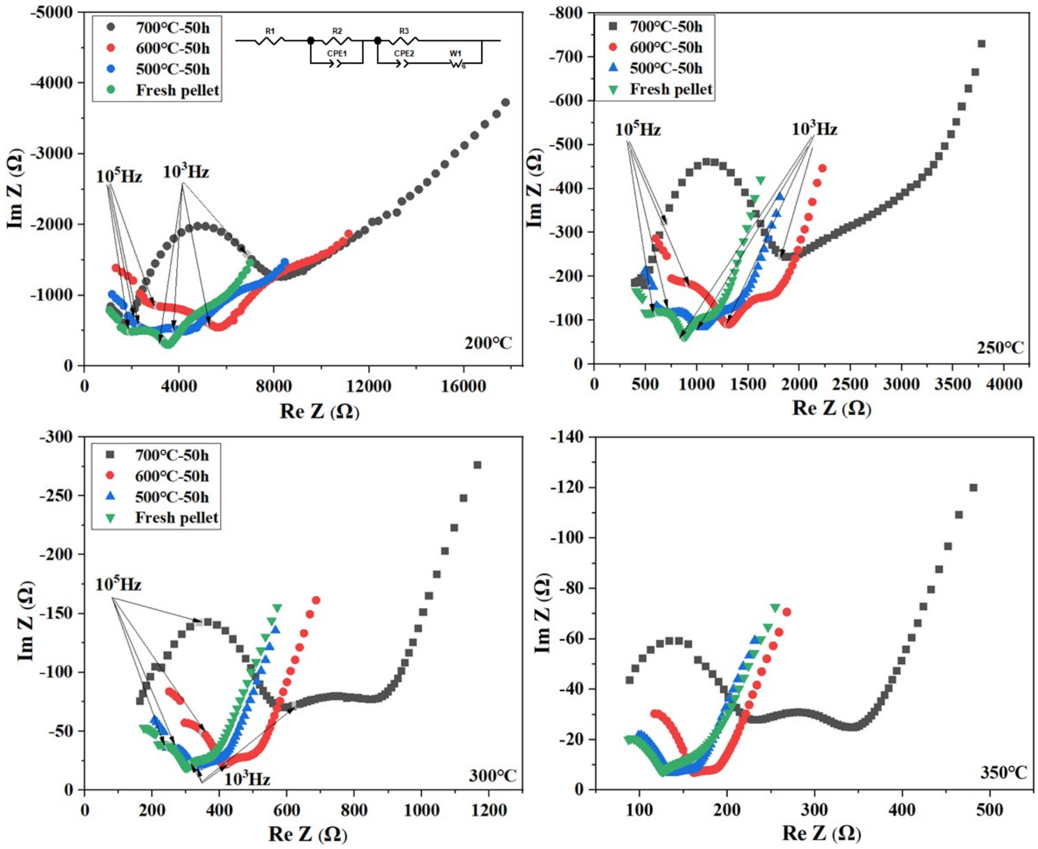
Fig. S2 (a) XPS full survey spectra, (b) Cr 2p core levels on the surface of BZCYYb1711 electrolyte pellets under rib of Fe-Cr alloy in humidified air at 400 ℃ for 20 h. (c)XPS full survey spectra on the surface of BZCYYb1711 electrolyte pellets under channel and rib of Fe-Cr alloy in humidified air at 700 ℃ for 20 h.

Fig. S3 EDS spectra of BZCYYb1711 surface under (a) channel and (b) rib of Fe-Cr alloy in humidified air at 700 ℃ for 20 h.



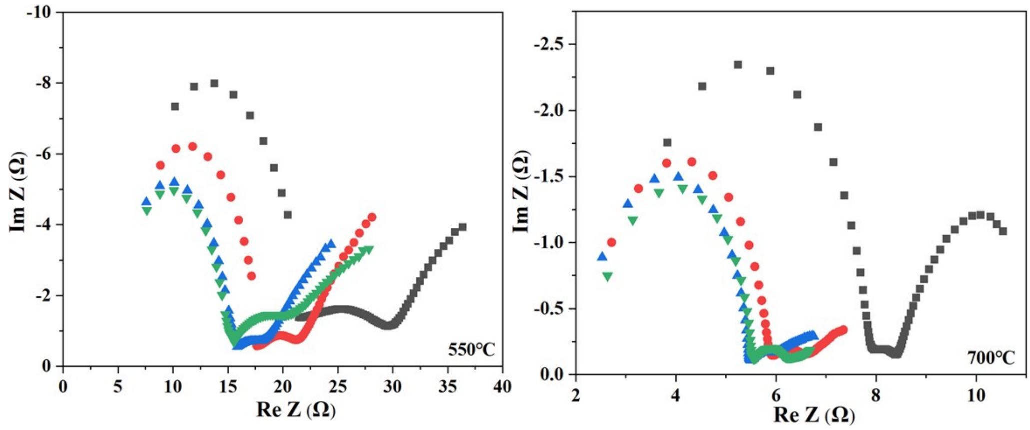


Fig. S4 Typical EIS spectra of BZCYYb1711 before and after being in direct contact with Fe-Cr alloy at humidified air for 50 h and measured at different temperatures.

Table S1. The binding energy of Cr 2p doublets at humidified air conditions.

	Cr^{6+}		Cr^{3+}	
500℃ (gaseous Cr)	579.2 eV	588.4 eV	586.4 eV	576.7 eV
600℃ (gaseous Cr)	579.2 eV	588.4 eV	586.0 eV	577.4 eV
700℃ (gaseous Cr)	579.1 eV	588.3 eV	585.9 eV	577.1 eV
700℃ Fe-Cr/rib	579.1 eV	588.3 eV	586.4 eV	578.7 eV
700℃ Fe-Cr/channel	579.1 eV	588.3 eV	586.5 eV	578.3 eV

Table S2. Relative ratios of Cr with different valence states derived by fitting the XPS core-level spectra of BZCYYb1711 electrolyte pellets after exposure to the gaseous Cr species and humidified air at 400-700℃ for 20 h.

Temperature (℃)	Cr^{3+} (%)	Cr^{6+} (%)
400	—	—
500	12.5	87.5
600	10.4	89.6
700	8.7	91.3

Table S3. Element ratio of electrolyte surface area exposed to rib and channel of Fe-Cr alloy in humidified air at 700℃ for 20 h.

Element	Position	
	Channel (At%)	Rib (At%)
Cr	22.19	44.20
Ba	41.31	47.71
Zr	2.61	0.00
Ce	27.72	7.41
Y	2.93	0.07
Yb	3.24	0.61

Total	100.00	100.00

Table S4. Relative ratios of Cr with different valence states derived by fitting the XPS core-level spectra of BZCYYb1711 electrolyte pellets under channel and rib of Fe-Cr alloy in humidified air at 700°C for 20 h.

Position	Cr^{3+} (%)	Cr^{6+} (%)
Channel	10.6	84.7
Rib	8.9	85.8

Table S5. Element ratio of cross-section of BZCYYb1711 electrolyte under rib of Fe-Cr alloy in humidified air at 700°C for 20 h.

Element	Region		
	(i)	(ii)	(iii)
Cr	48.25	21.63	—
Ba	50.17	26.55	49.90
Zr	—	5.04	4.93
Ce	1.58	35.71	34.49
Y	—	5.14	5.03
Yb	—	5.93	5.65
Total	100.00	100.00	100.00

Equations used to calculate conductivity of electrolyte:

$$R_{total} = R_{bulk} + R_{gb} \quad (1)$$

$$\sigma = \frac{L}{SR_{\mathrm{total}}} \quad (2)$$

where L, S, and R_{total} represent the thickness of electrolyte, area of electrode, and total resistance, respectively.