

Enhanced oxygen electrode performance in solid oxide fuel cells via La-doping of Pr₂NiO_{4+δ}-based Ruddlesden-Popper perovskites

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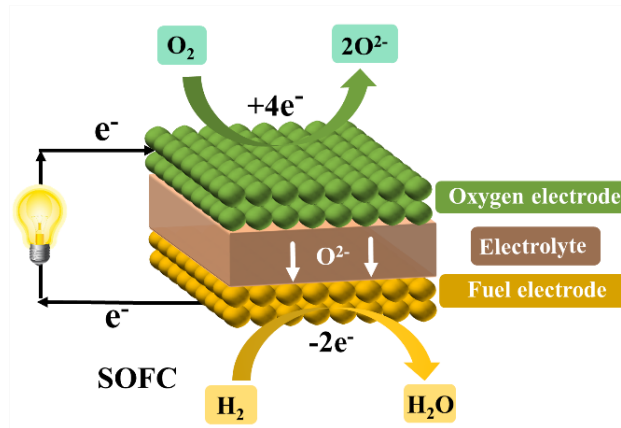


Fig. S1 Diagram of the structure and working principle of the SOFC.

Table S1 Rietveld fitting results for $\text{Pr}_{2-x}\text{La}_x\text{Ni}_{0.8}\text{Cu}_{0.2}\text{O}_{4+\delta}$ ($x=0, 0.5, 1.0$).

Sample	a (Å)	b (Å)	c (Å)	Volume(Å ³)	Chi ²	Crystal system	Space groups
PNC	5.431	5.403	12.531	367.69	1.77	Orthorhom bic	Fmmm
PL _{0.5} NC	5.425	5.425	12.585	370.35	1.62	Tetragonal	P4 ₂ /ncm
PL _{1.0} NC	5.432	5.432	12.647	373.17	1.38	Tetragonal	P4 ₂ /ncm

Table S2. Thermal expansion coefficients of PNC, PL_{0.5}NC, PL_{1.0}NC and common electrolyte.

	PNC	PL _{0.5} NC	PL _{1.0} NC	YSZ	LSGM	GDC	SDC
TEC(*10 ⁻⁶ K ⁻¹)	13.55	14.04	13.89	14.58	12.13	12.39	11.42

Table S3. ECR equilibration time of PNC, PL_{0.5}NC and PL_{1.0}NC.

Sample	650 °C	700 °C	750 °C	800 °C
PNC	723 s	480 s	359 s	287 s
PL _{0.5} NC	522 s	342 s	258 s	208 s
PL _{1.0} NC	630 s	433 s	284 s	223 s

Table S4. Oxygen surface exchange coefficient of PNC, PL_{0.5}NC and PL_{1.0}NC.

Sample	650 °C	700 °C	750 °C	800 °C
PNC (cm·s ⁻¹)	2.45×10 ⁻³	5.71×10 ⁻³	5.07×10 ⁻³	7.84×10 ⁻³
PL _{0.5} NC (cm·s ⁻¹)	3.90×10 ⁻³	7.85×10 ⁻³	8.62×10 ⁻³	9.80×10 ⁻³
PL _{1.0} NC (cm·s ⁻¹)	3.76×10 ⁻³	4.73×10 ⁻³	7.11×10 ⁻³	7.96×10 ⁻³

Table S5. Oxygen bulk diffusion coefficient of PNC, PL_{0.5}NC and PL_{1.0}NC.

Sample	650 °C	700 °C	750 °C	800 °C
PNC (cm ² ·s ⁻¹)	3.05×10 ⁻⁴	3.13×10 ⁻⁴	6.0×10 ⁻⁴	6.2×10 ⁻⁴
PL _{0.5} NC (cm ² ·s ⁻¹)	3.15×10 ⁻⁴	4.32×10 ⁻⁴	6.5×10 ⁻⁴	7.78×10 ⁻⁴
PL _{1.0} NC (cm ² ·s ⁻¹)	2.67×10 ⁻⁴	3.01×10 ⁻⁴	3.73×10 ⁻⁴	6.63×10 ⁻⁴

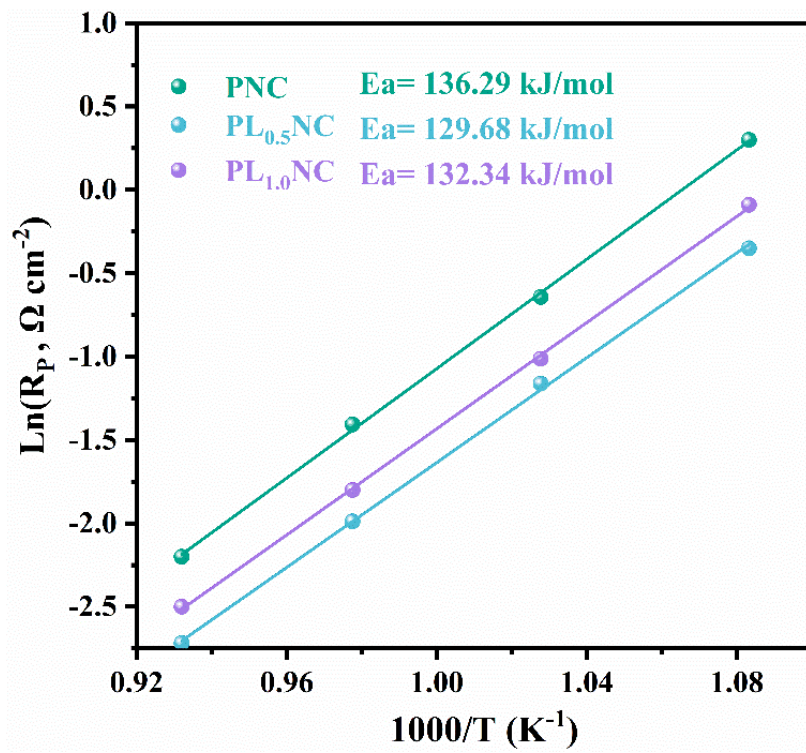


Fig. S2. Arrhenius plots of PNC, $\text{PL}_{0.5}\text{NC}$ and $\text{PL}_{1.0}\text{NC}$ electrodes.

Table S6. Impedances and peak power densities of different oxygen electrode $\text{Pr}_2\text{-}_x\text{La}_x\text{Ni}_{0.8}\text{Cu}_{0.2}\text{O}_{4+\delta}$ ($x=0, 0.5, 1.0$) single cells in SOFC mode.

Oxygen electrode	Performance	650 °C	700 °C	750 °C	800 °C
PNC	R_{Ω} ($\Omega \text{ cm}^2$)	0.591	0.415	0.310	0.234
	R_p ($\Omega \text{ cm}^2$)	1.933	1.375	0.655	0.272
	PPD (mW cm^{-2})	124	216	341	528
$\text{PL}_{0.5}\text{NC}$	R_{Ω} ($\Omega \text{ cm}^2$)	0.564	0.385	0.288	0.245
	R_p ($\Omega \text{ cm}^2$)	0.965	0.452	0.263	0.189
	PPD (mW cm^{-2})	317	467	649	864
$\text{PL}_{1.0}\text{NC}$	R_{Ω} ($\Omega \text{ cm}^2$)	0.587	0.405	0.297	0.240
	R_p ($\Omega \text{ cm}^2$)	1.414	0.791	0.345	0.218
	PPD (mW cm^{-2})	161	272	431	643