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

High-performance Ruddlesden-Popper perovskite oxide with *in-situ* exsolved nanoparticles for direct CO_2 electrolysis

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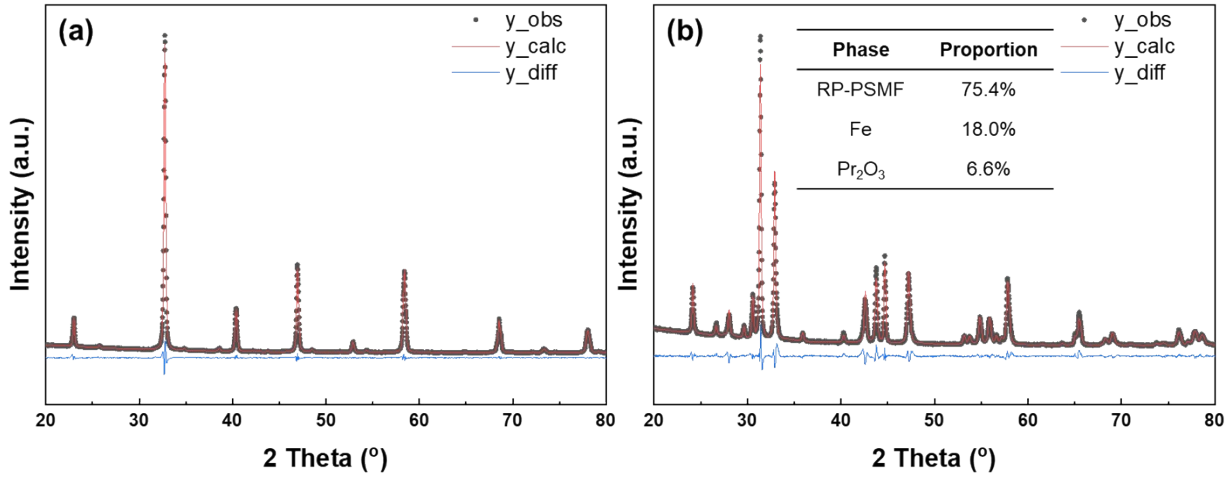

Figure S1. Rietveld refinement for XRD spectra fitted with observed (y_obs) and calculated (y_calc) XRD patterns, and the difference (y_diff) between the y_obs and y_calc: (a) PSMF and (b) RP-PSMF

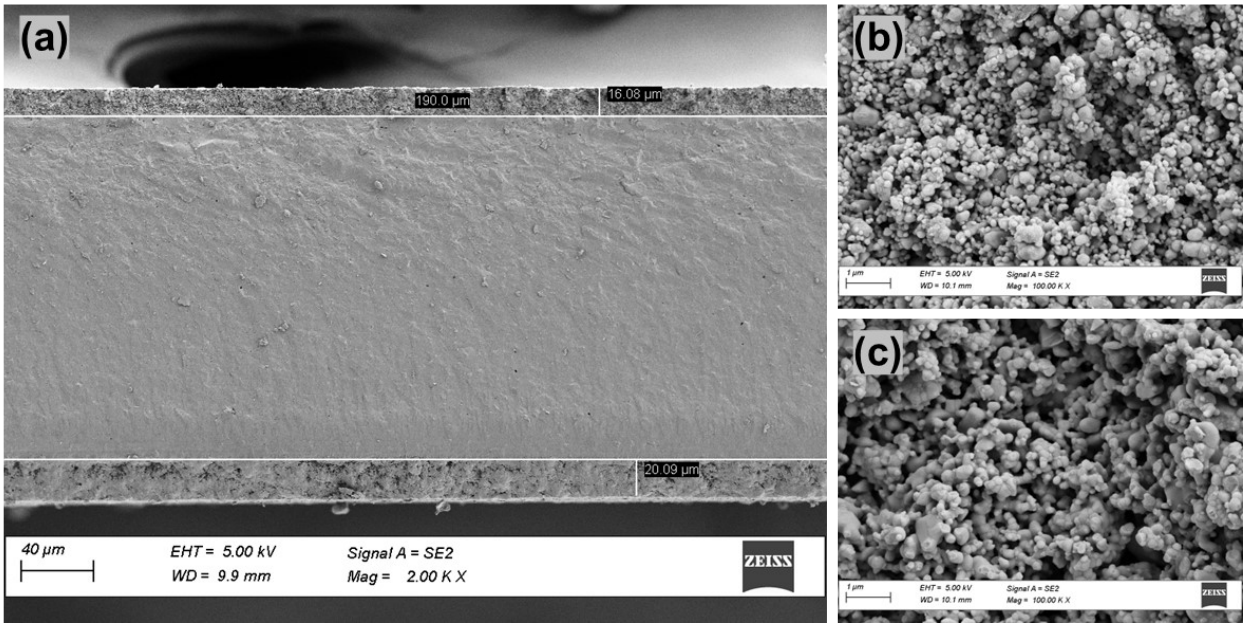

Figure S2. The SEM images of the LSGM electrolyte-supported cell (Configuration: PSMF-GDC │LSGM │LSCF-GDC) for direct CO_2 electrolysis operation: (a) cross-sectional image of the single cell, (b) LSCF-GDC, and (c) PSMF-GDC layers

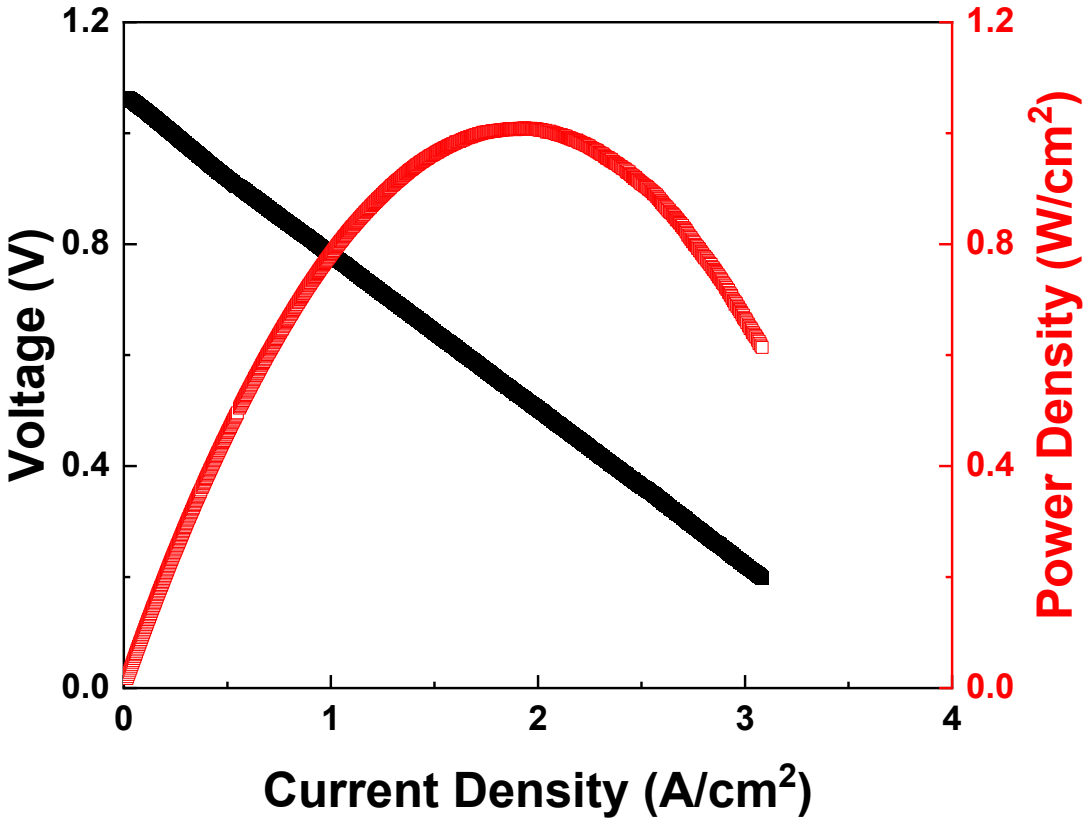

Figure S3. The current-voltage (*I-V*) polarization curve of the LSGM electrolyte-supported cell (Configuration: PSMF-GDC │LSGM │LSCF-GDC) at 800°C while feeding H_2 to fuel electrode and exposing ambient air to air electrode.

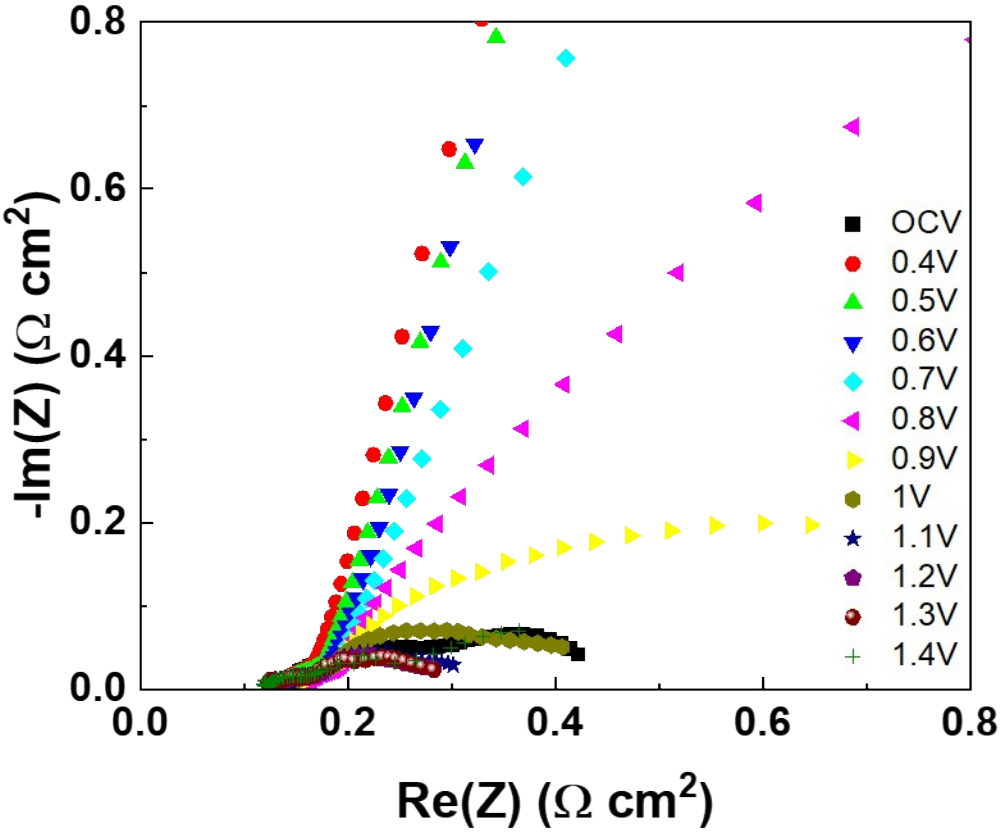

Figure S4. The EIS spectra of the LSGM electrolyte-supported cell (Configuration: PSMF/GDC │LSGM │LSCF/GDC) at 800°C under various applied voltages from OCV to 1.4V.

Table S1. The results of XPS fitting for the Fe $2P_{3/2}$ and Mn $2P_{3/2}$ peaks

PSMF

Fe $2P_{3/2}$ (χ^2 = 0.95)

Peak	Position(eV)	Area (%)	FWHM(eV)
Fe^0	-	-	-
Fe^{2+}	709.4	29.9	2.5
Fe^{3+}	710.7	46.4	2.8
Fe^{4+}	712.4	23.7	3.0

RP-PSMF

Fe $2P_{3/2}$ (χ^2 = 1.38)

Peak	Position(eV)	Area (%)	FWHM(eV)
Fe^0	705.9	20.6	3.0
Fe^{2+}	709.4	46.5	3.2
Fe^{3+}	710.7	32.9	3.3
Fe^{4+}	-	-	-

PSMF

Mn $2P_{3/2}$ (χ^2 = 1.56)

Peak	Position(eV)	Area (%)	FWHM(eV)
Mn^{2+}	-	-	-
Mn^{3+}	641.4	27.8	2.7
Mn^{4+}	642.1	72.2	2.9

RP-PSMF

Mn $2P_{3/2}$ (χ^2 = 1.83)

Peak	Position(eV)	Area (%)	FWHM(eV)
Mn^{2+}	640.4	53.9	3.6
Mn^{3+}	641.4	46.1	3.2
Mn^{4+}	-	-	-