

Boosting CO₂ Electrolysis via a Metal-Free F/Gd Co-doped CeO₂ Cathode for Solid Oxide Electrolysis Cells

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Table S1. The fitting data of XPS O 1s for FxGDC powders.

Relative concentration		GDC	F_{0.05}GDC	F_{0.1}GDC	F_{0.15}GDC
	O_L (%)	77.5	74.18	71.59	78.55
O 1s	O_S (%)	15.81	21.6	25.01	16.01
	-OH (%)	6.69	4.22	3.4	5.44

Table S2. The fitting data of XPS Ce 3d for FxGDC powders.

Relative concentration		GDC	F_{0.05}GDC	F_{0.1}GDC	F_{0.15}GDC
Ce 3d	Ce³⁺ (%)	11.26	15.15	16.7	15.14
	Ce⁴⁺ (%)	88.74	84.85	83.3	84.86
Average valence		3.887	3.849	3.833	3.849

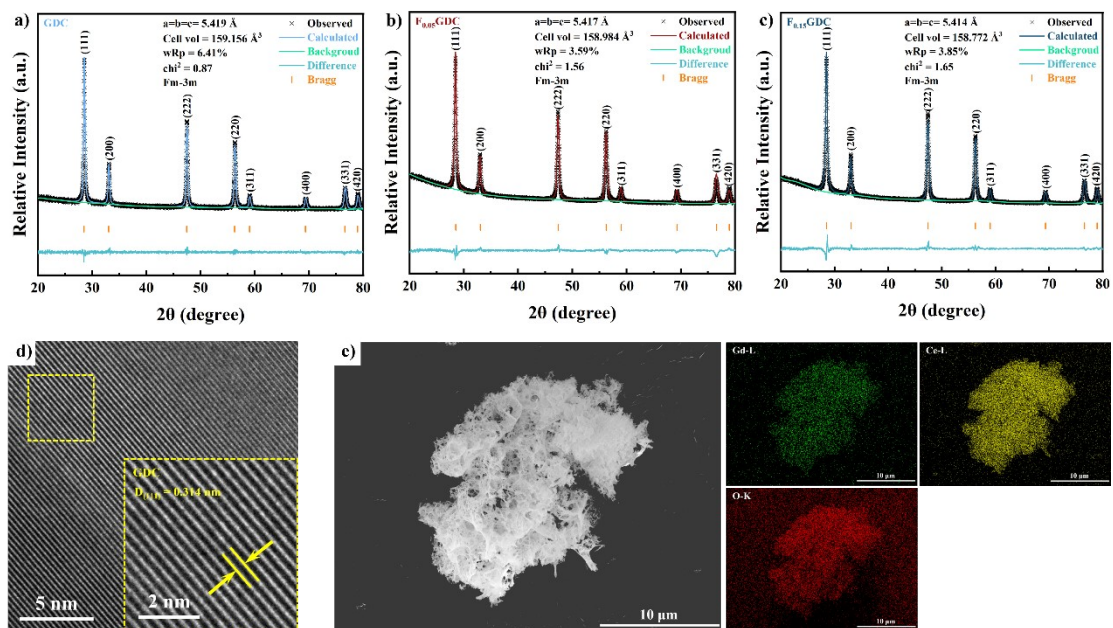


Figure S1. Rietveld refinement of the XRD pattern of (a) GDC; (b) $F_{0.05}GDC$; (c) $F_{0.15}GDC$; (d) TEM image of $F_{0.1}GDC$; (e) EDS spectrum of GDC.

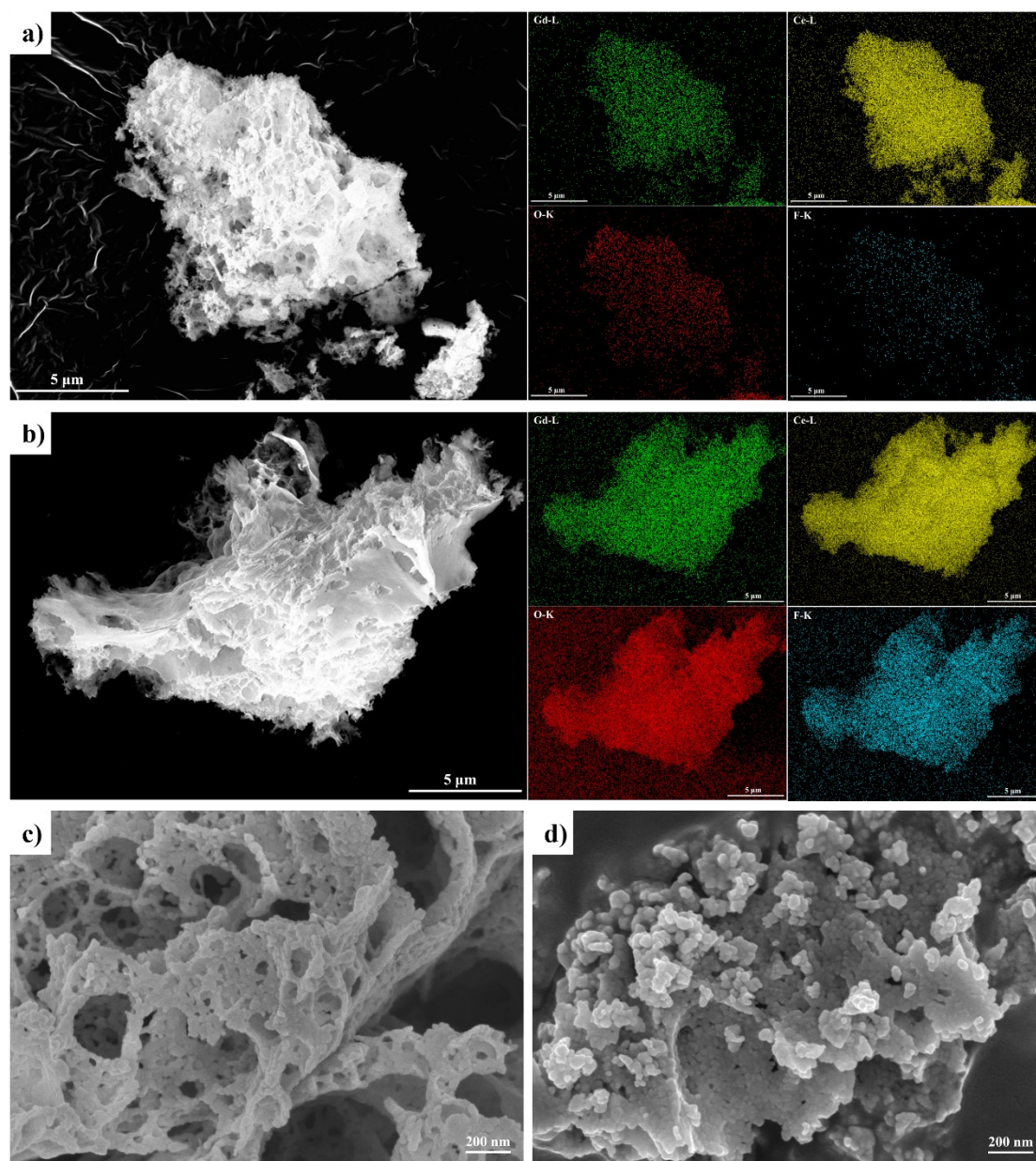


Figure S2. EDS spectrum of (a) $F_{0.05}GDC$; (b) $F_{0.15}GDC$; SEM image of (a) GDC powder; (b) $F_{0.1}GDC$ powder.

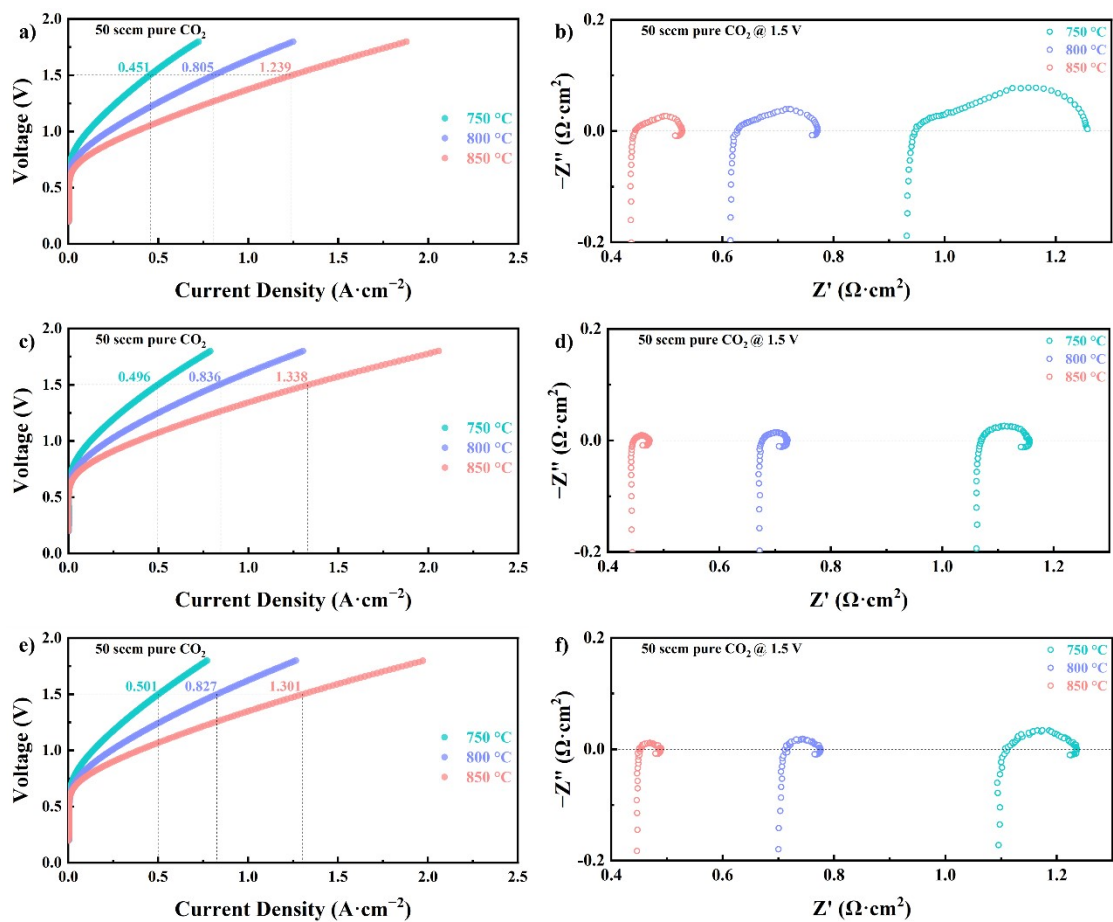


Figure S3. Electrochemical performance of cells with GDC, F_{0.05}GDC and F_{0.15}GDC as fuel electrode at different temperatures and applied voltage (a) I-V curves of GDC cell; (b) Impedance at different temperature at 1.5 V of GDC cell; (c) I-V curves of F_{0.05}GDC cell; (d) Impedance at different temperature at 1.5 V of F_{0.05}GDC cell; (e) I-V curves of F_{0.15}GDC cell; (f) Impedance at different temperature at 1.5 V of F_{0.15}GDC cell.

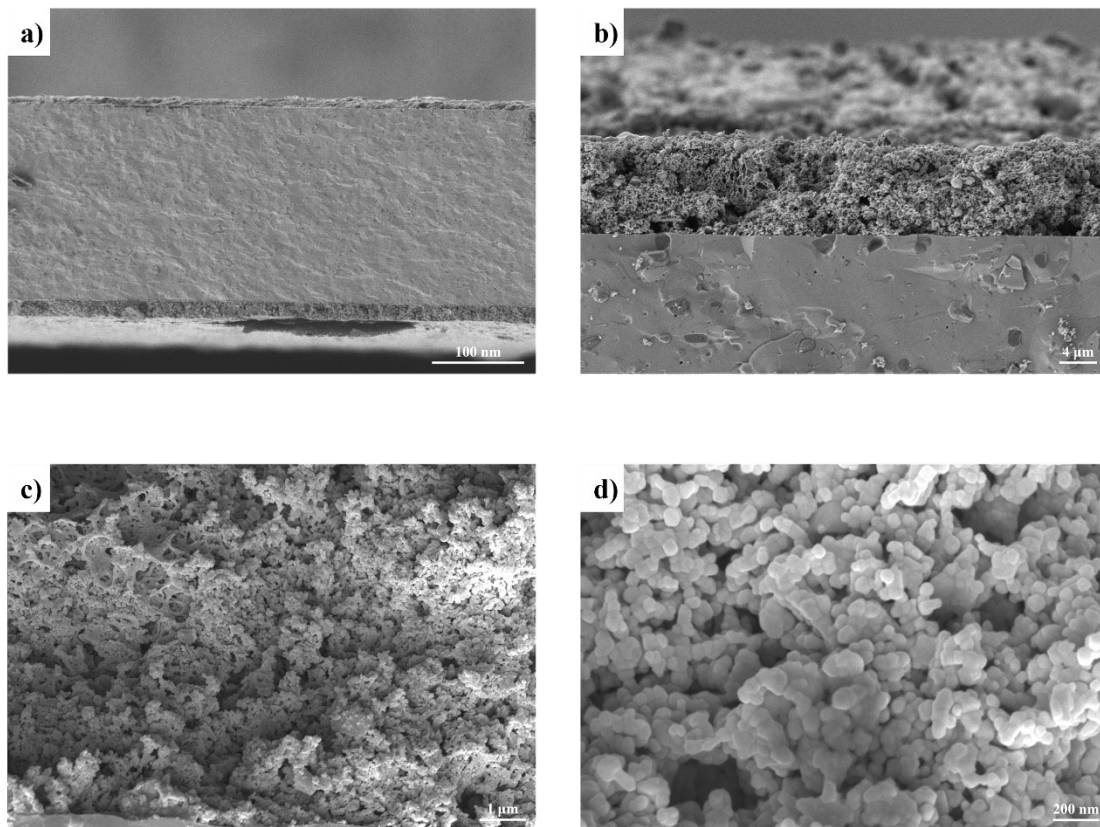


Figure S4. SEM images of the cell with $F_{0.1}GDC$ as fuel electrode after long term test. (a) SEM image of the entire cell. (b) SEM image of the $F_{0.1}GDC$ fuel electrode. (c) Amplification of the $F_{0.1}GDC$ fuel electrode. (d) Further amplification of the $F_{0.1}GDC$ fuel electrode

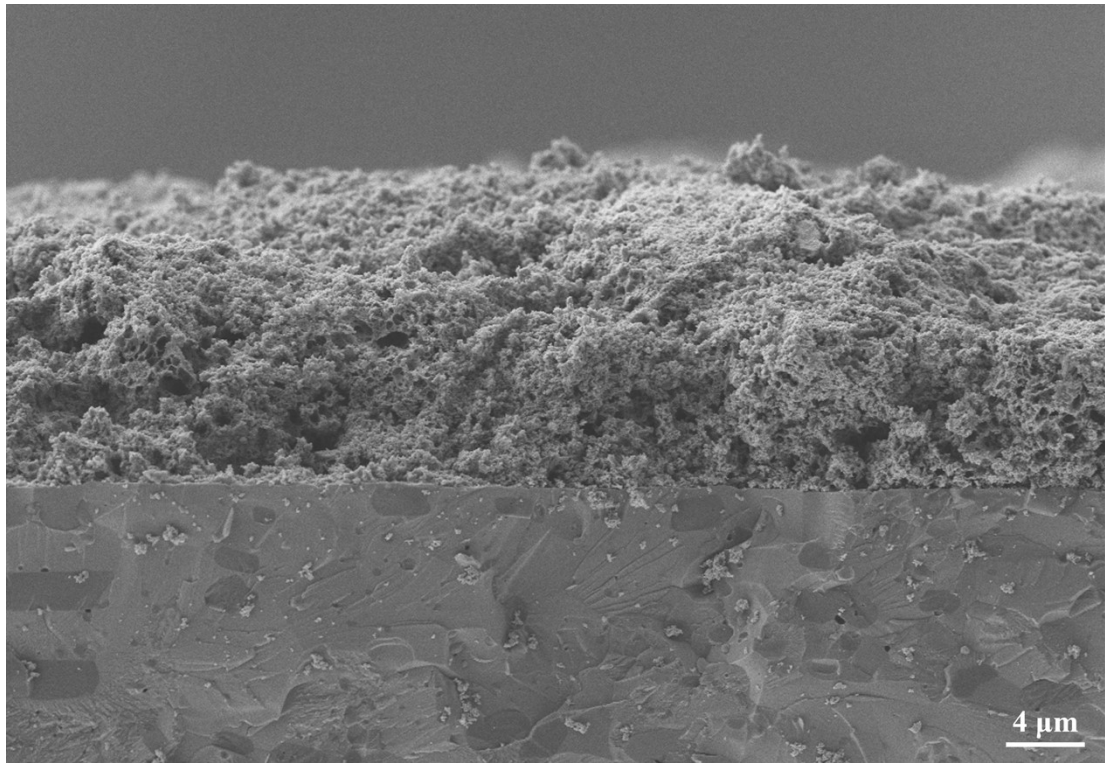


Figure S5. SEM images of the pristine cell with F_{0.1}GDC as fuel electrode