Supporting Information

Compositionally Graded Ni–YDC Thin-Film Anodes via Oblique Angle Sputtering for Low-Temperature SOFC

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Table S1. Porosity of the Ni–YDC thin-film anodes as a function of Ni deposition power..

	N90Y	N110Y	N130Y	N150Y
Porosity	12.37%	15.48%	19.26%	22.14%

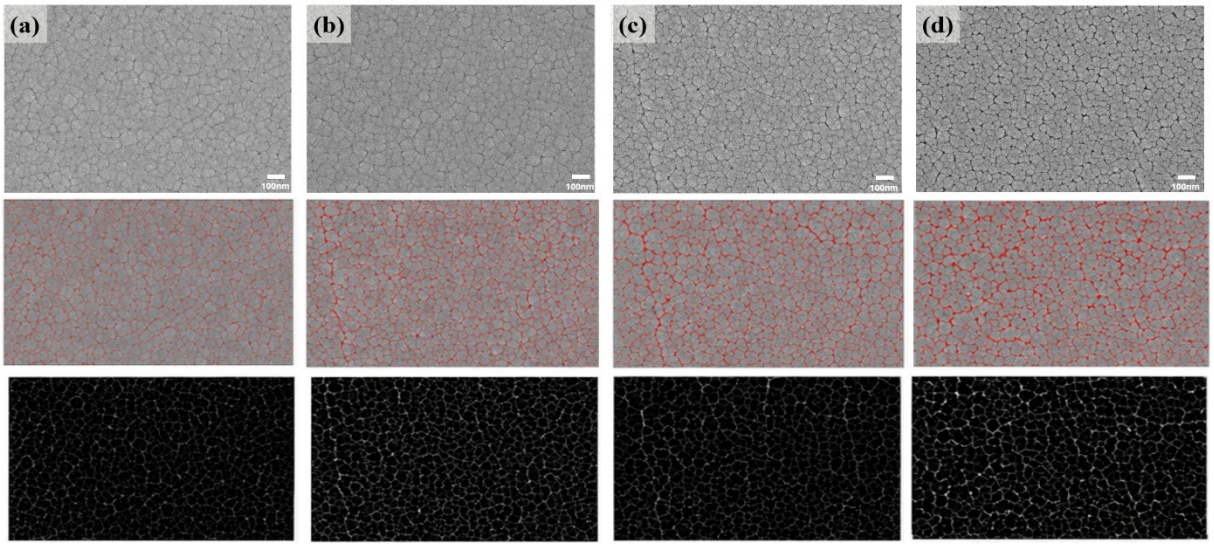

Figure S1. Surface morphology of single-layer Ni–YDC thin films (a) N90Y, (b) N110Y, (c) N130Y, and (d) N150Y. The corresponding surface porosities are summarized in Table S1

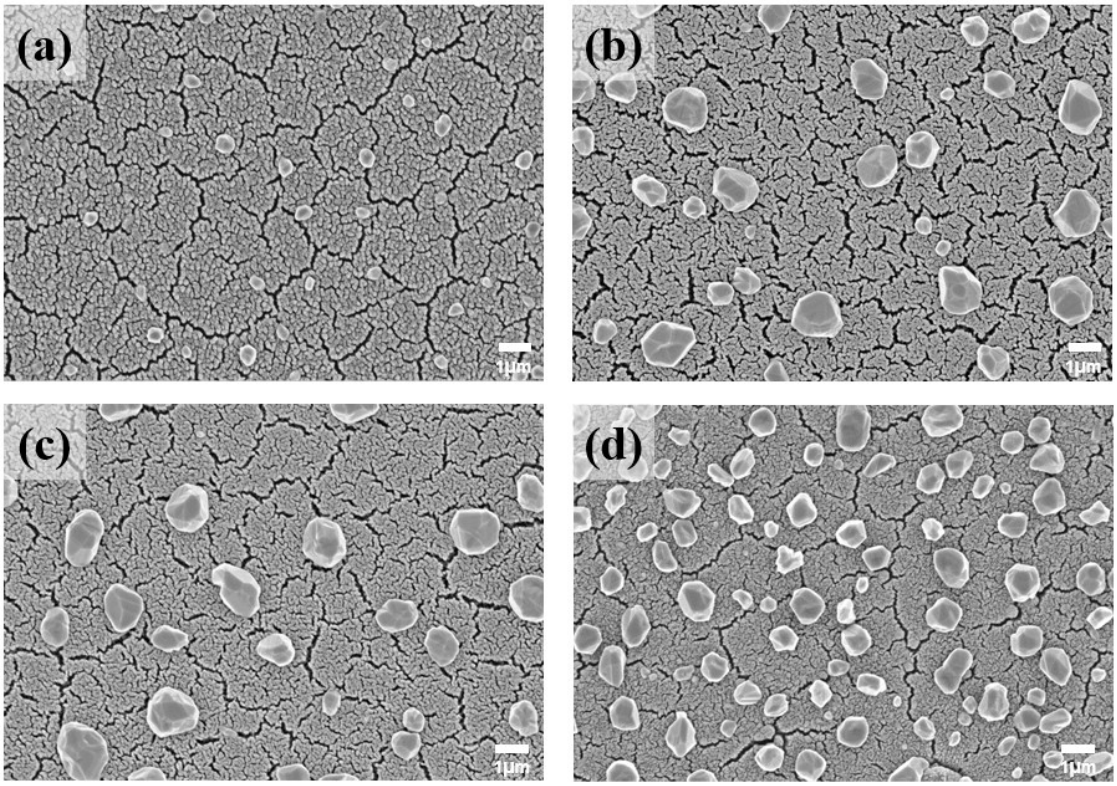

Figure S2. FESEM microstructural analysis of single-layer Ni–YDC thin-film anodes deposited on Si wafers. (a–d) Surface morphology after 6 hours of thermal reduction at 500 °C for: (a) N90Y, (b) N110Y, (c) N130Y, and (d) N150Y.

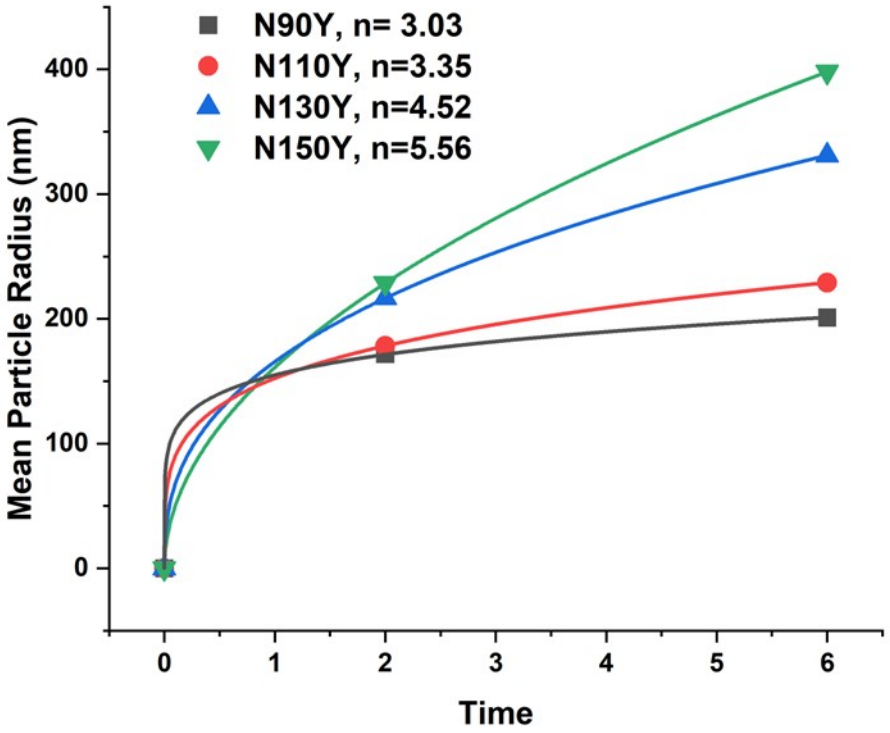

Figure S3. Time-dependent growth of surface Ni particle radius during operation at 500 °C, overlaid with the fitted power-law coarsening kinetics.

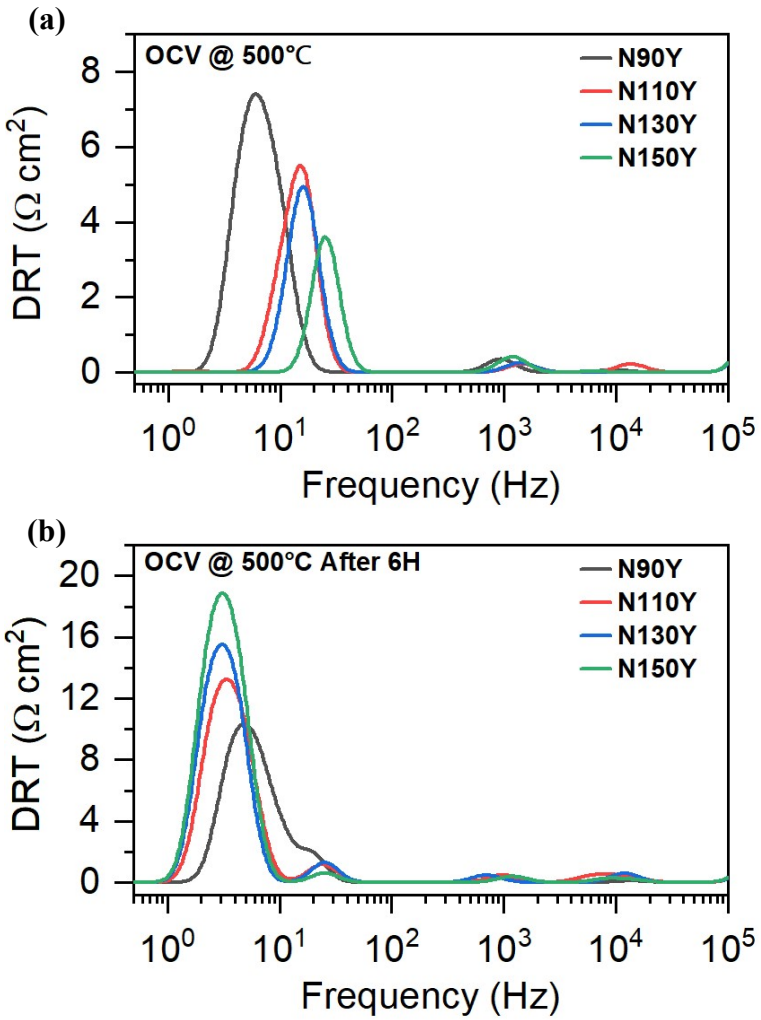

Figure S4. Distribution of relaxation times (DRT) analysis for electrolyte-supported SOFCs featuring N90Y, N110Y, N130Y, and N150Y anodes at 500 °C. (a, b) DRT spectra derived from the impedance spectra measured (a) initially and (b) after 6 hours of operation under OCV conditions.

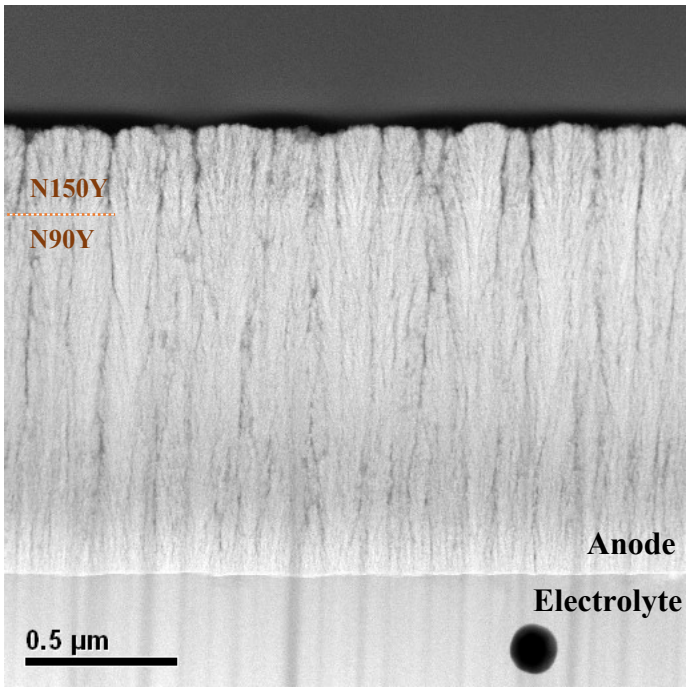

Figure S5. Cross-sectional Scanning Transmission Electron Microscopy (STEM) image of Cell#2-1. The compositionally graded Ni–YDC thin-film anode consists of an N150Y layer at the electrolyte interface and an N90Y layer at the channel interface.

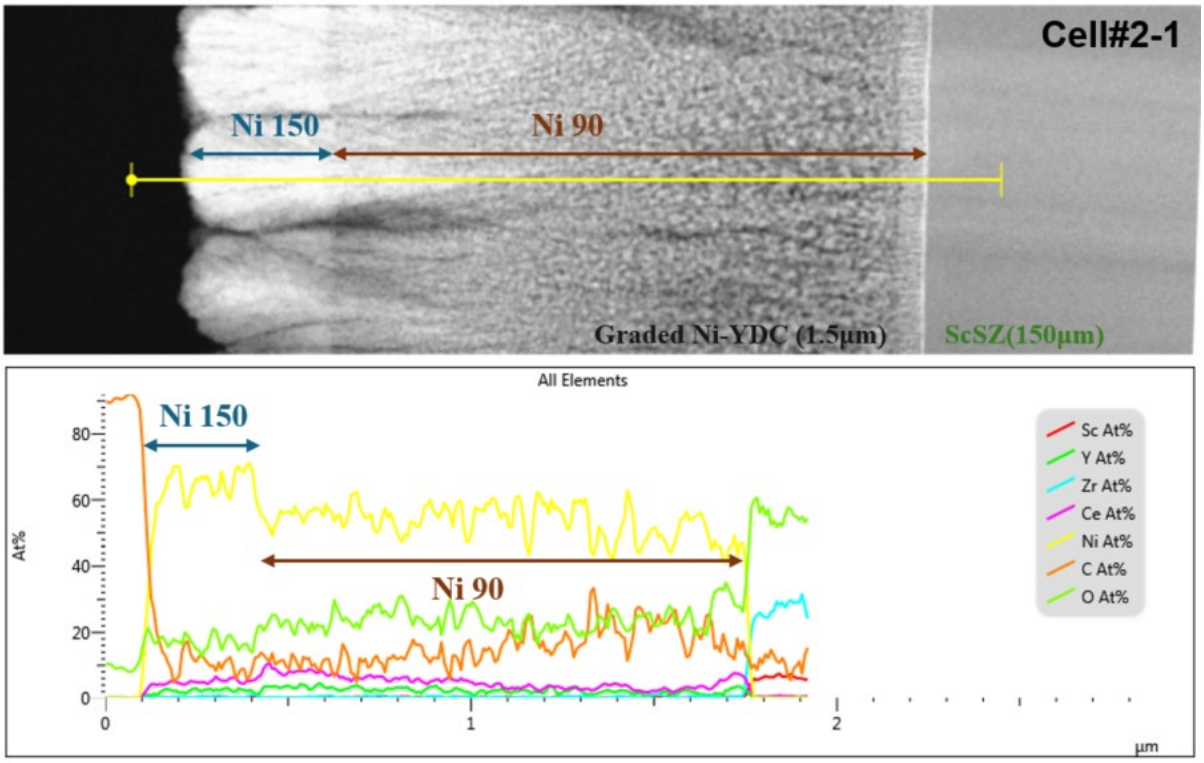

Figure S6. Microstructural and chemical analysis of the Cell#2-1 fuel electrode after 6 hours of operation: (a) TEM-EDS line-scan profiles showing atomic concentration gradients across the fuel electrode and interface after the 6-hour durability test.

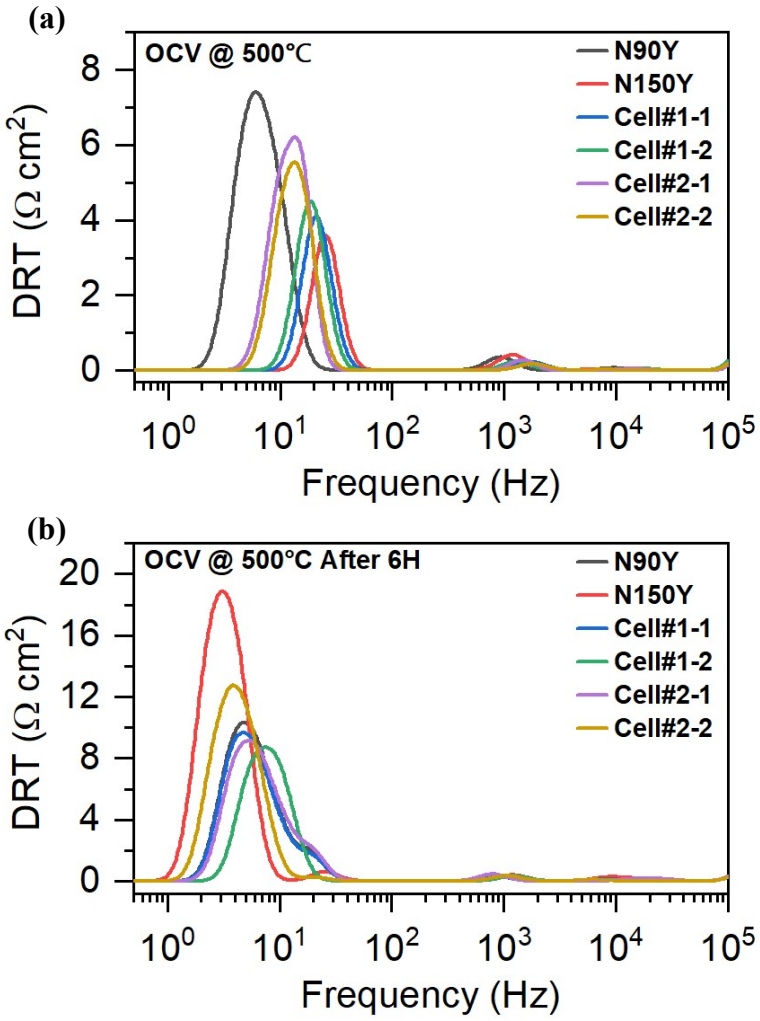

Figure S7. Distribution of relaxation times (DRT) analysis for electrolyte-supported SOFCs comparing reference cells (N90Y and N150Y) and compositionally graded Ni–YDC anode cells (Cell#1-1, Cell#1-2, Cell#2-1, and Cell#2-2) at 500 °C. (a, b) DRT spectra derived from the impedance spectra measured (a) initially and (b) after 6 hours of operation under OCV conditions..