Electronic Supplementary Material (ESI) for Nanoscale.


**Supporting information:**

# Boosting performance and durability of Ni/YSZ cathode via decoration with ultrafine CGO electro-catalyst for hydrogen production at high current densities

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**Initial characterizations:**

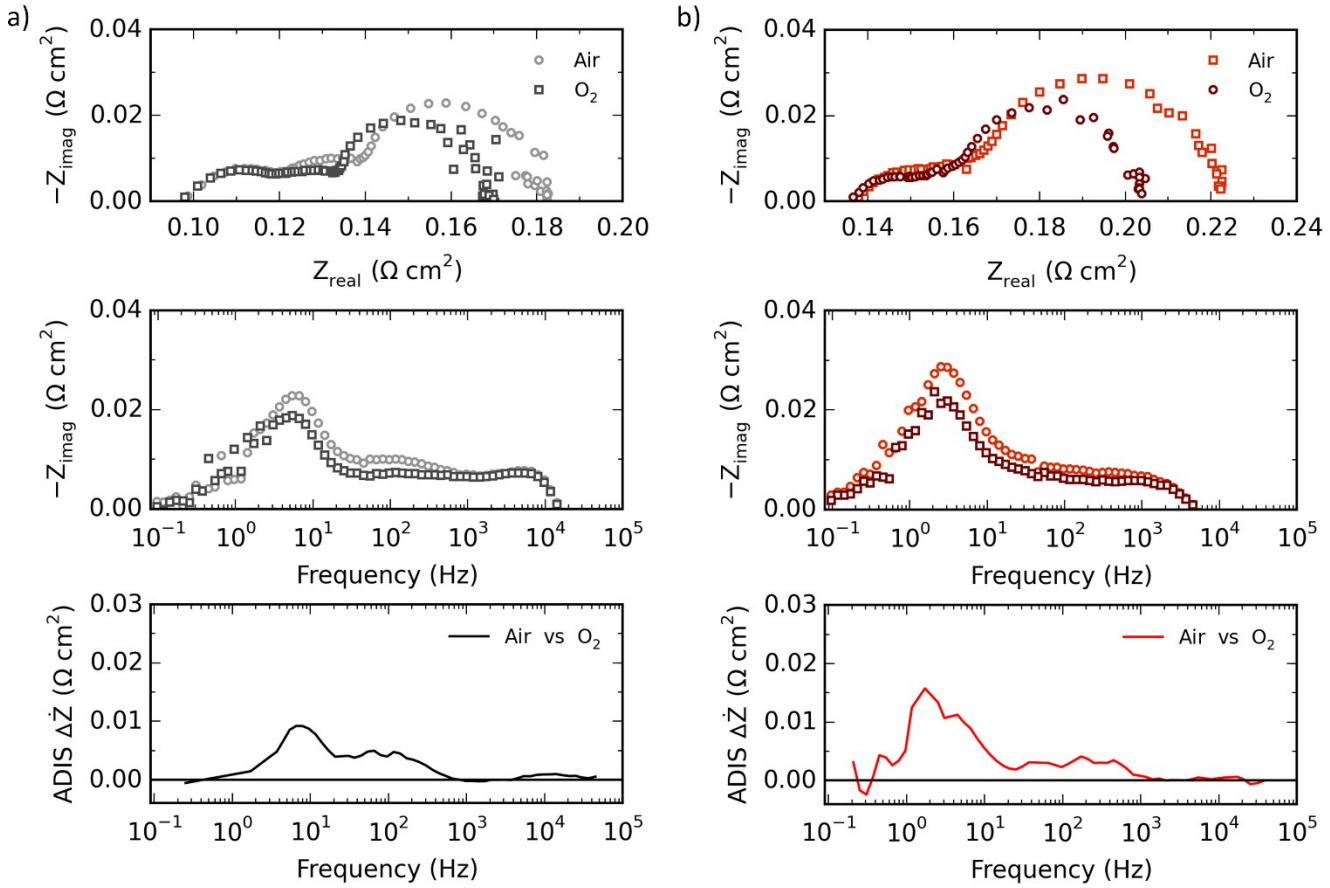


*Figure S1: EIS of a) Cell A, and b) Cell B1 for oxygen electrode gas shift with corresponding ADIS plot where EIS measured by applying air was taken as a reference.*

**Durability tests:**

Table S1: Cell voltages and resistances measured during the long-term durability test for Cell A with the bare Ni/YSZ electrode and Cell B1 with the CGO infiltrated Ni/YSZ electrode.

| | Cell A | | | Cell B1 | | |
|---|---|---|---|---|---|---|
| Time (h) | 0 | 60 | 750 | 0 | 500 | 1000 |
| Voltage (V) | 1.265 | 1.365 | 1.789 | 1.218 | 1.251 | 1.332 |
| Rs (mΩ cm$^2$) | 77.4 | 100.6 | 368.0 | 130.5 | 121.0 | 125.7 |
| Rp (mΩ cm$^2$) | 383.7 | 407.8 | 439.8 | 208.0 | 268.0 | 431.7 |

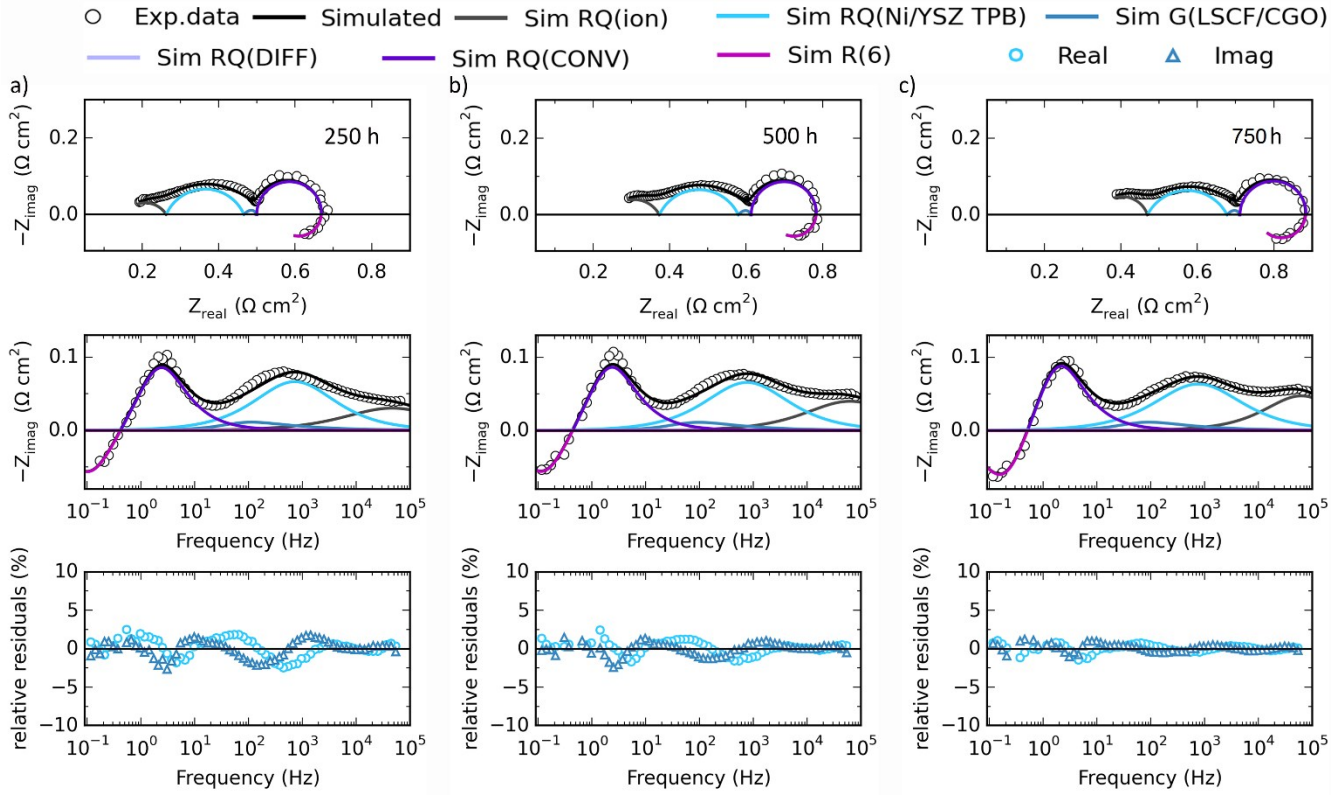


*Figure S2: Results of fitting equivalent circuit models to the impedance spectra for Cell A during long-term steam electrolysis at −1.25 A/cm$^2$, 800 °C and 70% steam conversion: a) 250h, b) 500h, and c) 750h*

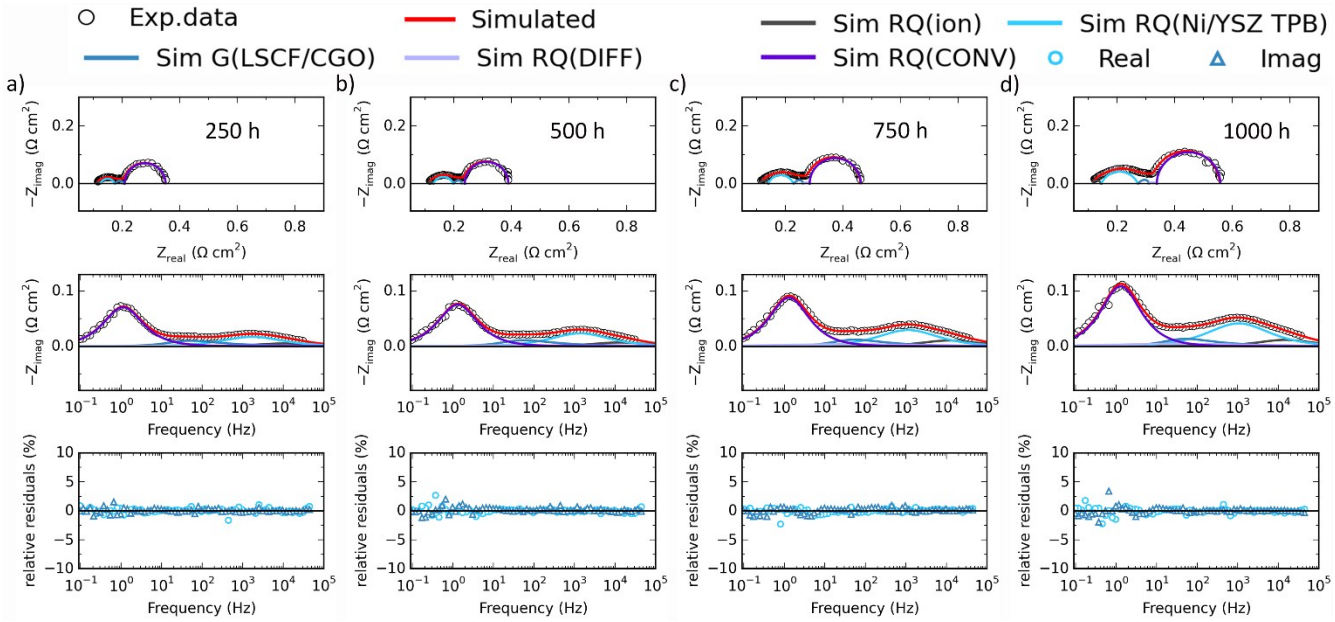


*Figure S3: Results of fitting equivalent circuit models to the impedance spectra for Cell B1 during long-term steam electrolysis at −1.25 A/cm², 800 °C and 70% steam conversion: a) 250h, b) 500h, c) 750h, and d) 1000h*

Table S2: Results of fitting equivalent circuit models to the impedance spectra for Cell A and Cell B1 during long-term steam electrolysis at −1.25 A/cm², 800 °C and 70% steam conversion (results from Figure S2 and Figure S3). The estimated uncertainty for the simulated resistances is ~±7 mΩ cm².

| R (Ω cm²) | Cell A | | | | Cell B1 | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | 0h | 250h | 500h | 750h | 0h | 250h | 500h | 750h | 1000h |
| $R_s$ | 0.067 | 0.154 | 0.240 | 0.338 | 0.117 | 0.111 | 0.110 | 0.113 | 0.113 |
| $R_{ion}$ | 0.013 | 0.109 | 0.132 | 0.132 | 0.009 | 0.014 | 0.019 | 0.029 | 0.031 |
| $R_{Ni/YSZ\ TPB}$ | 0.187 | 0.203 | 0.206 | 0.208 | 0.038 | 0.051 | 0.069 | 0.088 | 0.128 |
| $R_{LSCF/CGO}$ | 0.026 | 0.031 | 0.031 | 0.032 | 0.027 | 0.028 | 0.031 | 0.034 | 0.038 |
| $R_{DIFF}$ | 0.003 | 0.002 | 0.003 | 0.002 | 0.006 | 0.006 | 0.010 | 0.023 | 0.027 |
| $R_{CONV}$ | 0.164 | 0.171 | 0.173 | 0.176 | 0.145 | 0.147 | 0.151 | 0.179 | 0.219 |
| $R_P$ | 0.393 | 0.516 | 0.545 | 0.550 | 0.225 | 0.246 | 0.280 | 0.353 | 0.443 |

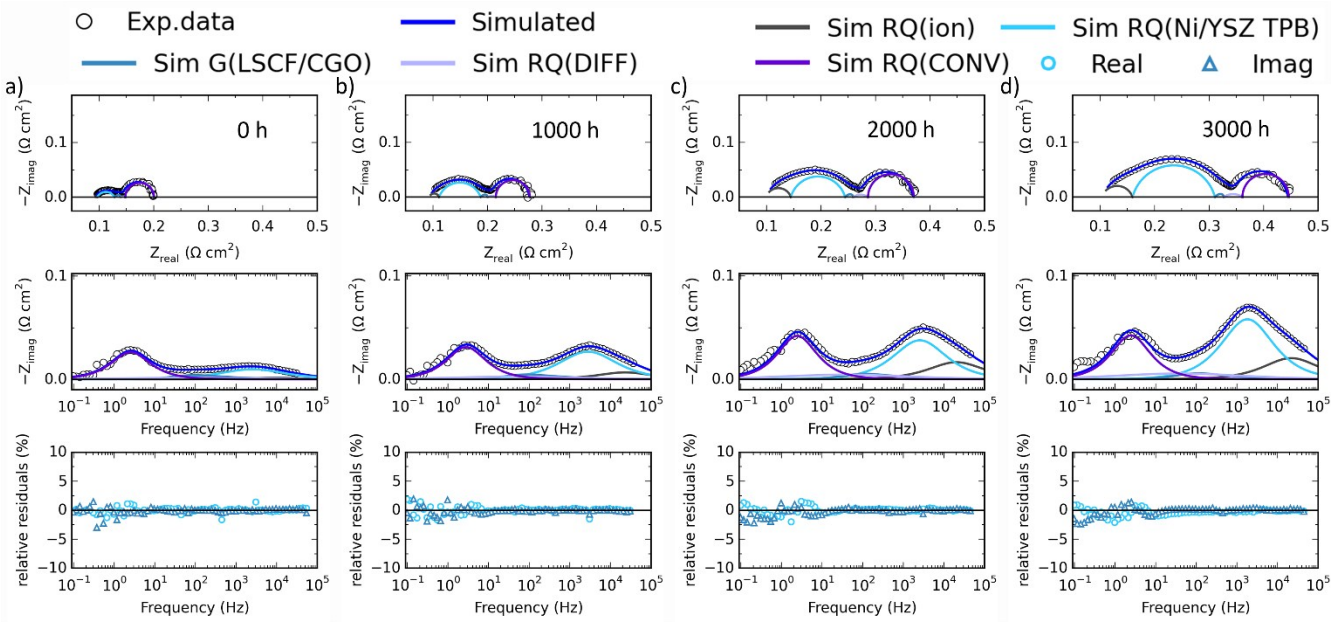


*Figure S4: Results of fitting equivalent circuit models to the impedance spectra for Cell B2 during long-term test under -1.25 A/cm² (11test104) a) 0 h and b) 1000 h, c) 2000 h, d) 3000 h (under -1.25 A/cm²)*

Table S3: Results of fitting equivalent circuit models to the impedance spectra for Cell B2 during long-term steam electrolysis at −1.25 A/cm², 800 °C and 42% steam conversion (results from Figure S4). The estimated uncertainty for the simulated resistances is ~±6 mΩ cm².

| R (Ω cm²) | Cell B2 | | | | | | |
|---|---|---|---|---|---|---|---|
| | 0h | 250h | 500h | 750h | 1000h | 2000h | 3000h |
| $R_s$ | 0.093 | 0.089 | 0.090 | 0.091 | 0.093 | 0.099 | 0.103 |
| $R_{ion}$ | 0.004 | 0.005 | 0.010 | 0.015 | 0.018 | 0.045 | 0.056 |
| $R_{Ni/YSZ\ TPB}$ | 0.032 | 0.044 | 0.050 | 0.060 | 0.076 | 0.100 | 0.151 |
| $R_{LSCF/CGO}$ | 0.011 | 0.012 | 0.013 | 0.013 | 0.013 | 0.015 | 0.016 |
| $R_{DIFF}$ | 0.009 | 0.012 | 0.013 | 0.015 | 0.015 | 0.027 | 0.034 |
| $R_{CONV}$ | 0.053 | 0.051 | 0.052 | 0.055 | 0.062 | 0.084 | 0.085 |
| $R_P$ | 0.109 | 0.124 | 0.138 | 0.158 | 0.184 | 0.271 | 0.342 |

**Microstructure of reference cells:**

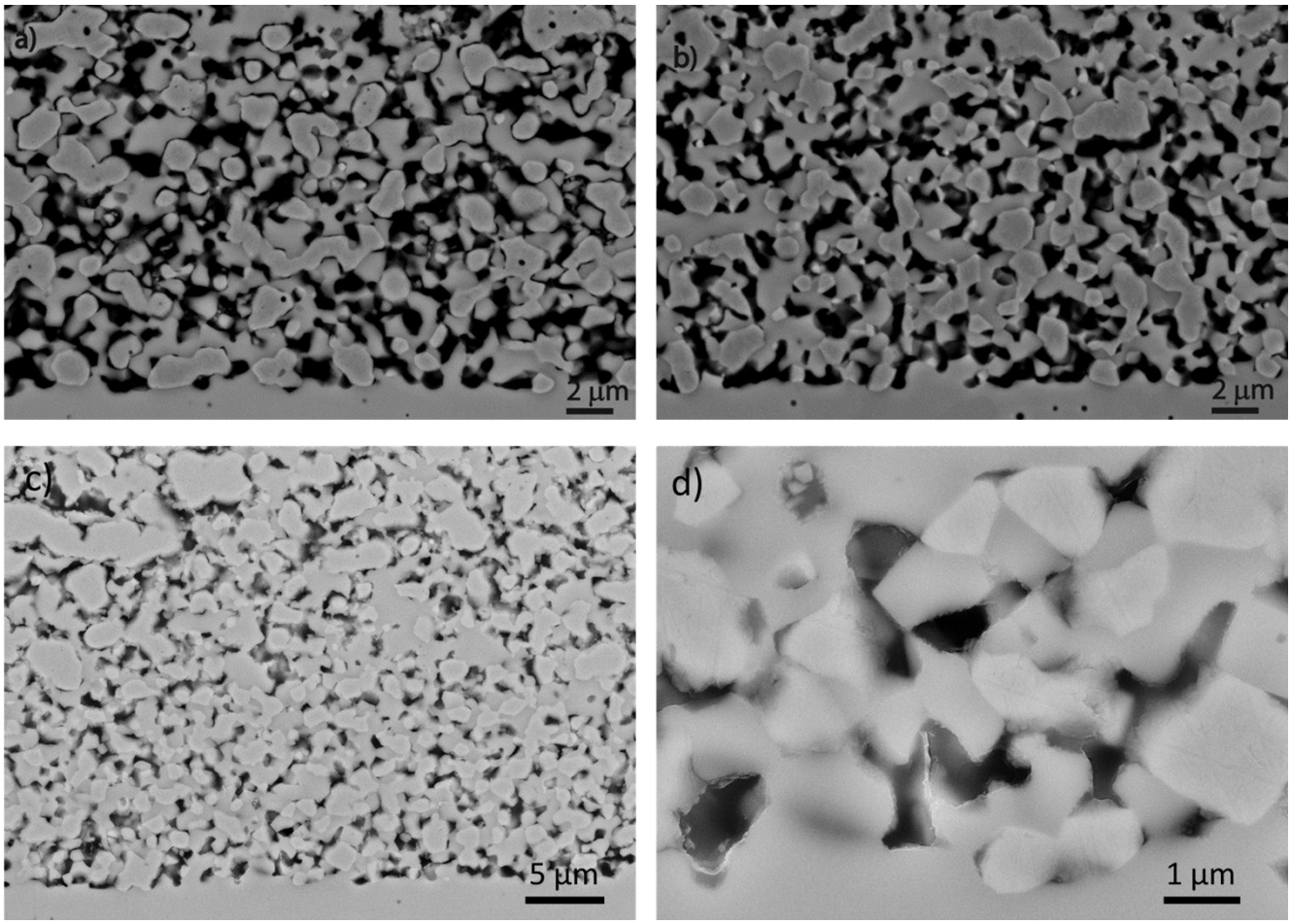


*Figure S5: a) Microstructure of Cell A after long term electrolysis test, b) Microstructure of polished cross-section of reduced Ni/YSZ backbone or a cell after short test. (c,d) Microstructure of Cell B1 after long term electrolysis test.*

**Parallel study on CGO particles growth in reducing atmosphere:**

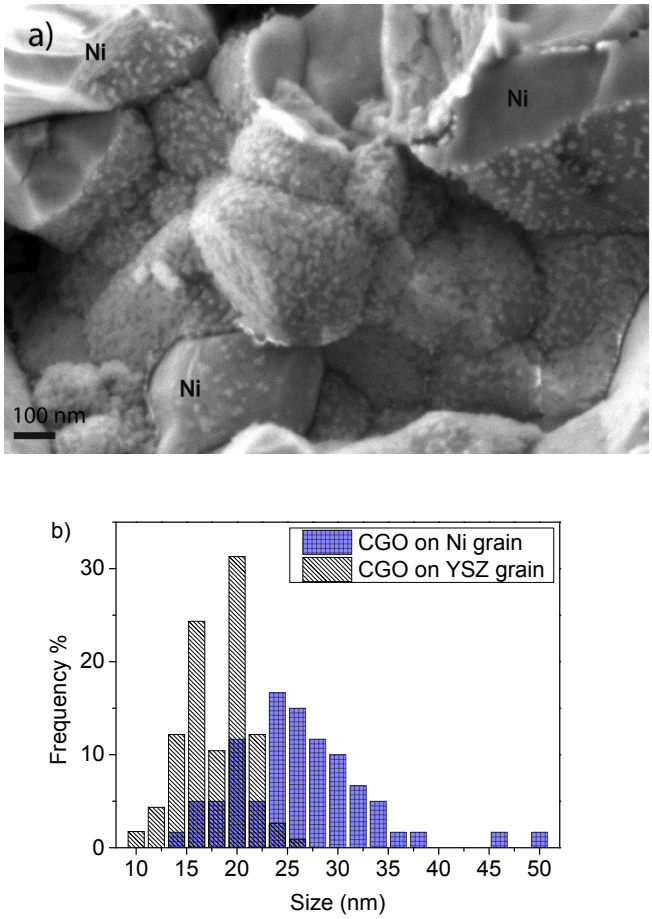


*Figure S6: a) Microstructure of CGO infiltrated particles after 600 h at 550 °C in wet $H_2/N_2$ atmosphere, b) with particles size distribution measured from more than 100 CGO particles on the Ni grains and on the YSZ grains.*