LNC-Cu Contact Paste: Performance Comparison to Traditional LSM Based Contact Pastes

Executive Summary

Lanthanum Nickel Cobalt - Copper Oxide (LNC-Cu) is a highly optimized mixture of perovskite-type ceramic and copper oxide. It is predominantly used as a current-collection layer (contact paste) in intermediate-temperature Solid Oxide Fuel (SOFCs) and Electrolysis (SOECs) Cells. This whitepaper summarizes the performance benefit of using LNC-Cu contact paste over traditional LSM-based contact paste materials.

Lanthanum Nickel Cobalt - Copper Oxide (LNC-Cu)

Nexceris' Lanthanum Nickel Cobalt Copper Oxide (LNC-Cu) is a highly engineered current-collection (contact paste) layer in intermediate temperature solid-oxide fuel cells and electrolyzers. The material's effectiveness derives from the use of lanthanum nickel cobaltite, which has metallic-like conductivity at SOFC operating temperatures. Copper oxide is added as a sintering aid to promote adhesion to both the air electrode and interconnect surfaces. The result is an effective contact paste material that provides a balance of high electronic and ionic conductivity and thermal and chemical stability.

Results

Cell Performance Testing

To validate the new LNC-Cu air-electrode contact paste, Nexceris' commercial 5 cm x 5 cm electrolyte-supported cells were tested with standard LSM and LNC-Cu air electrode contact pastes with all other experimental variables and conditions being held constant. SOFC performance was evaluated at 700°C, 750°C, and 800°C with a 50/50 mix of H_2/N_2 with a 0.5 SLPM flow rate. SOEC performance was conducted only at 800°C with 90% steam and 10% H_2 and the same total flow rate. Figure 1 shows the polarization curves for each condition and in all cases the cell tested with LNC-Cu contact paste outperforms the cell with LSM.

To better understand the impact of the contact pastes on the cell performance, electrochemical impedance spectroscopy (EIS) tests were conducted at each condition at OCV and under a bias. For SOFC tests, the cell was biased to 0.8V and for SOEC it was 1.3V. Representative Nyquist charts are shown in Figure 2 for both conditions, as well as the equivalent circuit used for fits, also represented on the charts and inset in panel b.

Resistance values obtained from the fits were used to calculate ohmic, non-ohmic, and total area-specific resistances (ASR) for each cell and condition. R1 is assigned to ohmic, and the sum of R2 and R3 is assigned to non-ohmic contributions. Figure 3 shows a series of bar charts comparing these results between the two contact pastes. Ohmic contributions are consistent at both OCV and under bias, as expected, and at every condition shows significantly higher ASR for the LSM

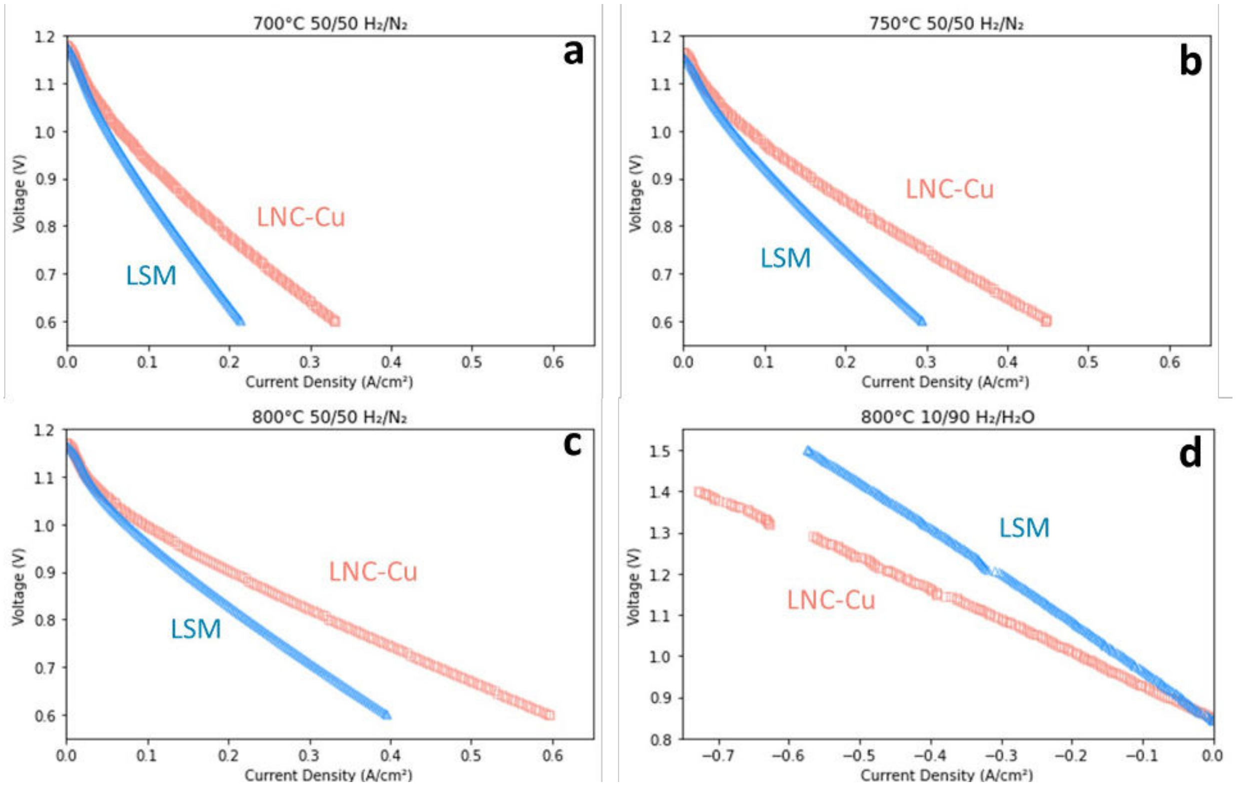

Figure 1. Polarization curves under different conditions: **a)** 700°C in 50% dry H_2, **b)** 750°C in 50% dry H_2, **c)** 800°C in 50% dry H_2, and **d)** 800°C in 90% steam & 10% H_2

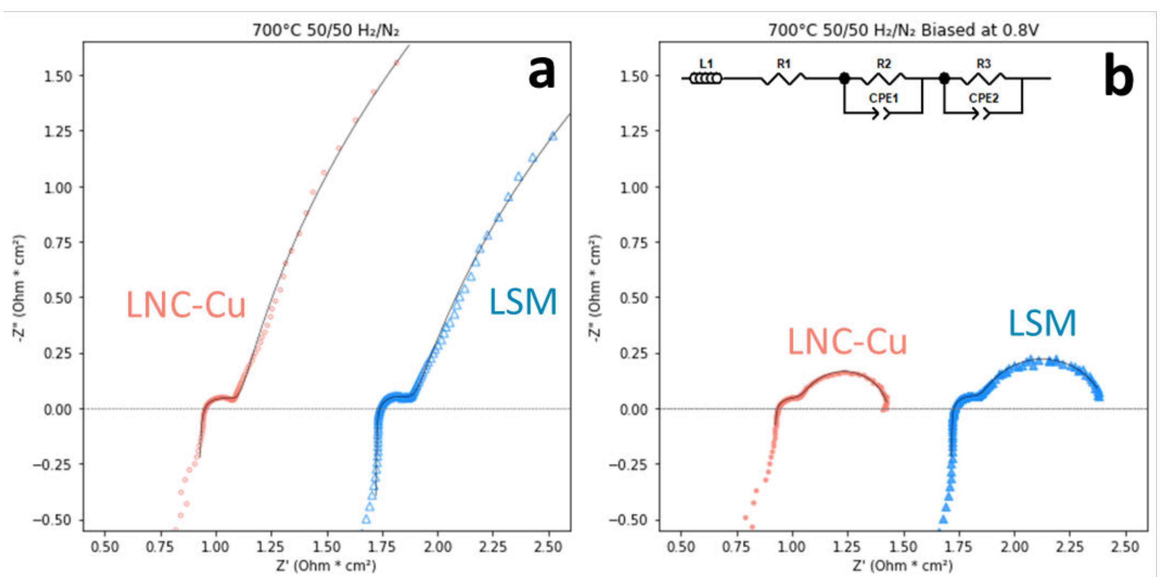

Figure 2. Representative Nyquist charts of EIS collected at 700°C with dry SOFC gas conditions at a) OCV, and b) 0.8V. Data is represented with markers and fit results by lines

cell. Non-ohmic contributions, however, show slightly higher ASR values for LNC-Cu at OCV, but are significantly lower than LSM under bias in SOFC mode. Under the electrolysis condition, the LNC-Cu non-ohmic ASR is slightly higher than that of LSM under bias, but both are very low at OCV. When polarized, the cell with LNC-Cu contact paste shows 59% to 66% of the total ASR of the cell with LSM contact paste across the four conditions.

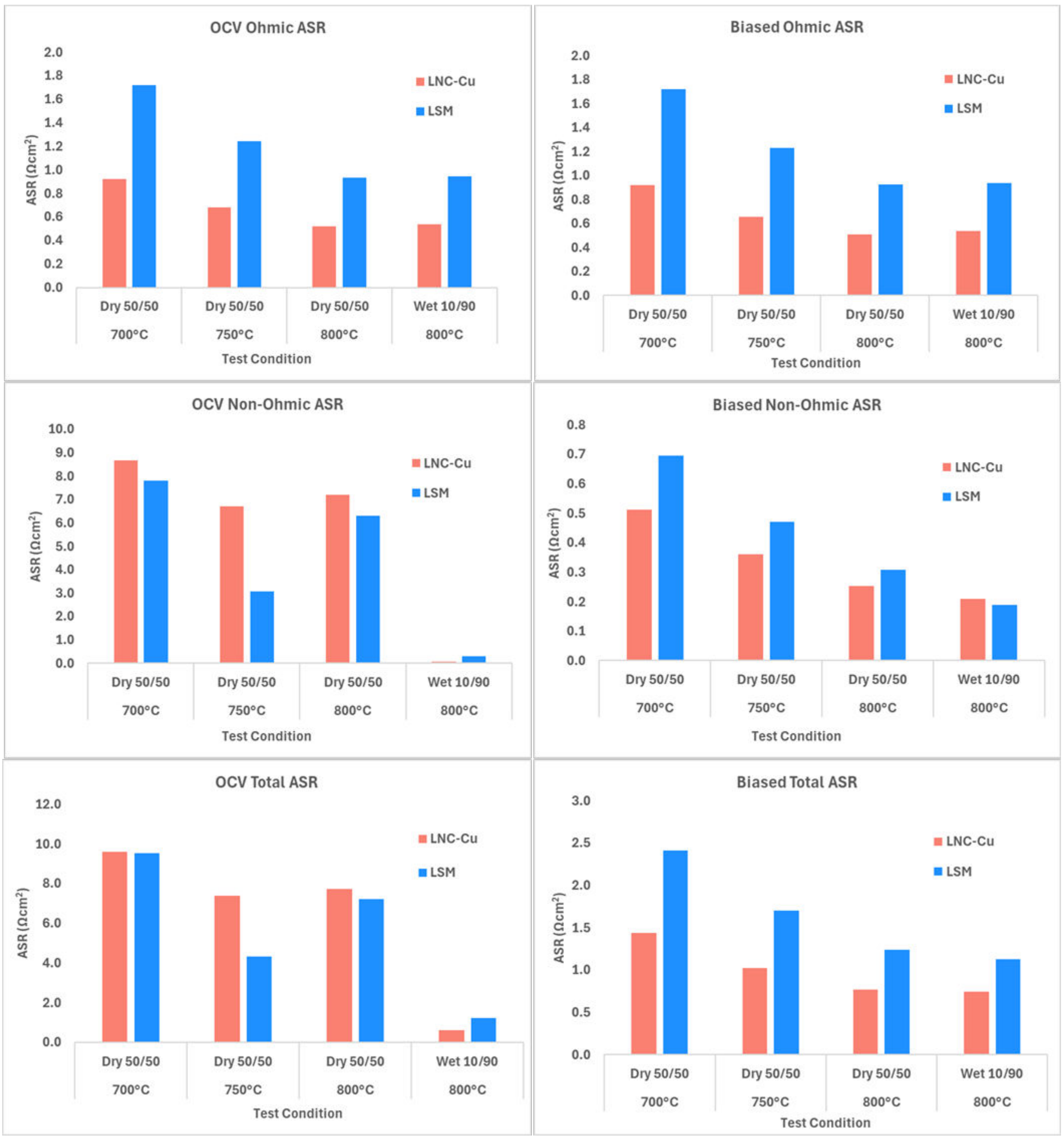

Figure 3. Comparative charts of ASR contributions for both contact pastes at both OCV (left) and under bias (right)

Finally, Figure 4 shows voltage change with time of a Nexceris 10-cell ESC stack tested under a constant current density of 0.6 A/cm^2. This stack utilized the same LNC-Cu contact paste on the air electrode as employed in the single cell tests shared above. Throughout the duration of this test, the stack saw a 1.05 %/kh increase in voltage, which is close to state-of-the-art. This shows that the LNC-Cu contact paste shows no major degradation over long-term use.

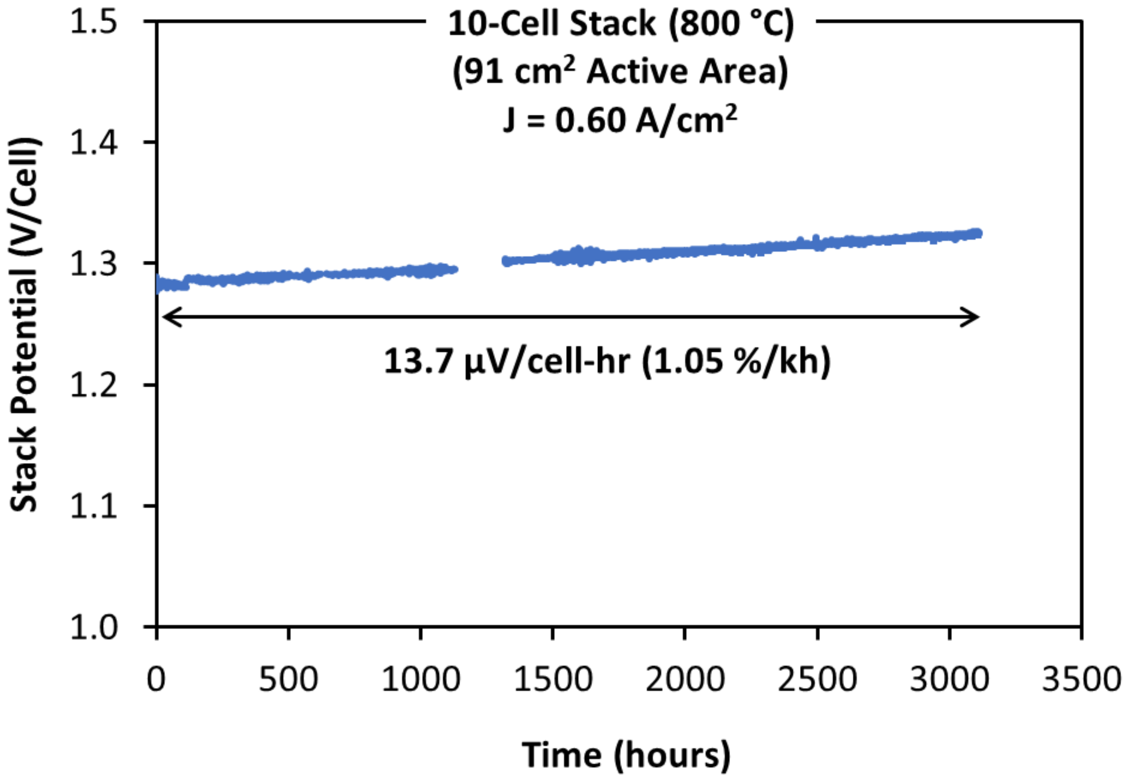

Figure 4. Over 3000 hours of internally tested 10-cell stack utilizing LNC-Cu contact paste on the air electrode.

Conclusions

LNC-Cu is a new contact paste that delivers higher cell performance than traditional LSM-based contact pastes under both SOFC and SOEC operating conditions due to lower overall resistance. Long duration stack testing shows good thermal stability over time and this contact paste can be readily applied to both electrolyte and anode-supported cell architectures.