Toward Next Generation Metal-Supported Solid Oxide Fuel Cells

Applicants: dr. D. Giuntini, Mechanical Engineering, TU Eindhoven; dr. D. Jafari, Advanced Manufacturing, Sustainable Products & Energy Systems, University of Twente.

Type of funding: Rapid research

We have successfully formulated colloidal suspension inks based on Nickel Oxide (NiO)-Yttria-stabilized Zirconia (YSZ) and Nickel Oxide (NiO)-Gadolinium-doped Ceria (GDC) to use them for 3D printing layered structures as a potential anode system for solid oxide fuel cells (SOFCs). We have been utilizing the ultra-high temperature sintering (UHS) technique for post treatment and consolidation of these structures. In summary, the achievements of the project as promised are as follows:

- Ink Formulation and full 3D printing of layered structures of a potential SOFC anode system
  - Ink rheological optimization
  - Printing process optimization
- UHS co-sintering of the layered structures and their structural characterizations
- Cross-comparison of UHS sintering vs. conventional sintering pathways with respect to the shrinkage and porosity formation of the 3D printed structures
- Preparing two research articles on the results of 3D printing + sintering study (article #1) and electrochemical performance of the printed and UHS-sintered samples (article #2)

With respect to the proposal's tasks, all have been tackled: Tailored porous structures have been developed (Task 1), Plasma Electrolytic Oxidation has been tested (Task 2) and a prototype of the planned new SOFC concept has been realized (Task 3). Feasibility of all these steps has been analyzed.

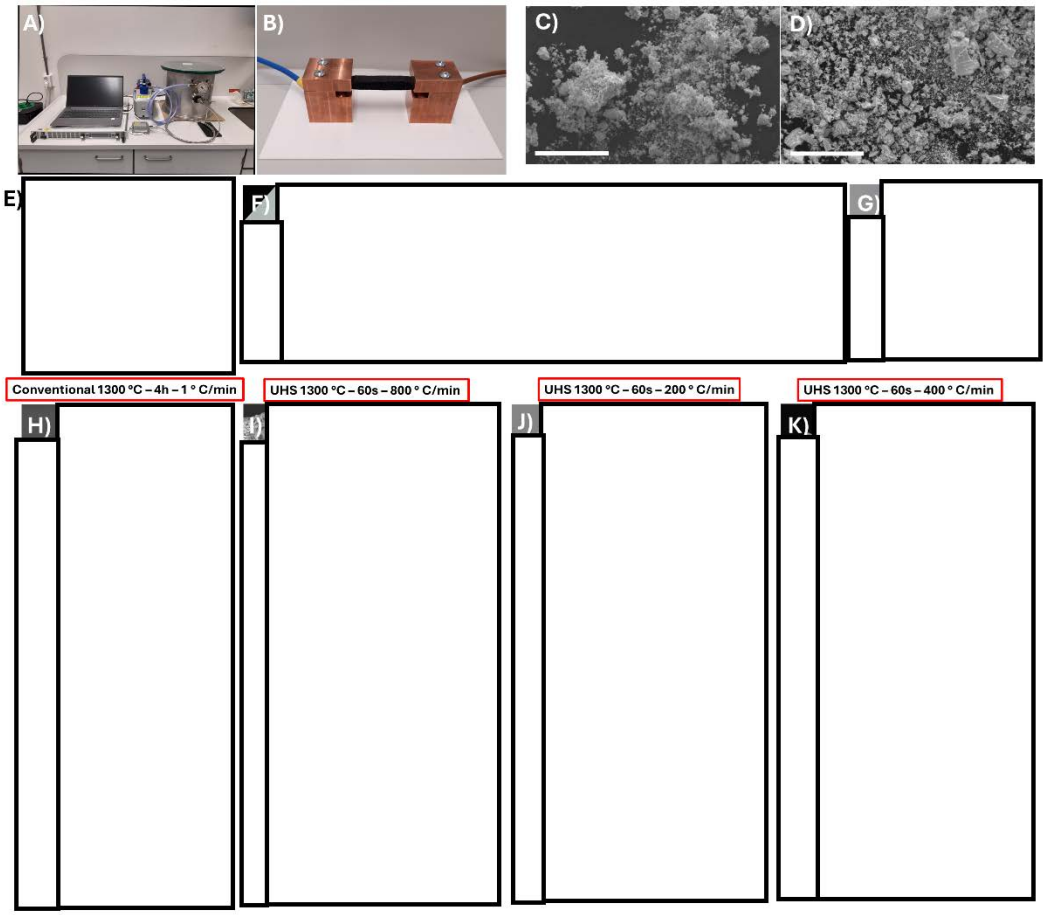

Figure 1. A) The primary components of the UHS setup and the connections between them, and B) the resistor, comprising two graphite felts that sandwich the sample to be sintered, C) SEM micrographs of NiO-GDC (scale bar: 30 µm), and D) NiO-YSZ (scale bar: 30 µm) as-received commercial powders, E) Plots of the dynamic viscosity as a function of shear rate of the inks formulations, F) A series of the printed layered structures comprising three layers of NiO-YSZ ink with high-loading of pore former, a layer of NiO-YSZ ink with low-loading of pore former, and a layer of NiO-GDC ink that has not pore former, G) the printed layered structures after debinding in air, and cross-sectional SEM micrographs of the top, middle and bottom parts of the fracture surfaces of the 3D printed layered structures after H) conventional sintering at Conventional 1300 °C for 4h at a 1 °C/min heating rate (scale bars: 10 µm), I) UHS sintering at 1300 °C for 60s at a heating rate of 800 °C/min (scale bar: 30 µm), J) UHS sintering at UHS 1300 °C for 60s at a heating rate of 200 °C/min (scale bars: 30 µm), and K) UHS sintering at 1300 °C for 60s at a heating rate of 400 °C/min (scale bars: 30 µm).

Plan for follow-ups

The applicant and co-applicant are currently planning applications for longer-term funding via NWO-AES instruments.

Academic publication forthcoming, after publication the pictures E-K will be published in this report.