Fabrication of solid oxide cells by ink-jet 3D printing

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INTRODUCTION

With increasing wind and solar energy production energy storage becomes increasingly important. Solid Oxide Cells (SOCs) can be used for energy storage since they offer efficient conversion of electricity to fuel and fuel to electricity. Today material costs and lifetime issues prevents a widespread deployment of the SOC technology. However, 3D printed SOCs can potentially result in significantly cheaper and more robust cells. The aim of the project is to construct an SOC electrolyte and electrode backbone using a PiXDRO 3D inkjet printer. First a printable suspension/ink must be created, which is compatible with the print head requirements in terms of viscosity, surface tension and particle size. When a proper ink is made, an electrolyte is printed and on top of this a porous backbone. This backbone can then be impregnated with an electrocatalyst after sintering to make a functional electrode.

THEORY

A single SOC have a cell voltage around 1 V. In order to reach a suitable voltage for power electronics SOCs are connected serially in a stack. Normally the SOCs are stacked individually with interconnect layers between the cells to avoid gas mixing. If Ink-jet printing can be used to print the entire SOC stack and the stack is sintered in one piece it can improve the contact between the various interfaces between the different layers in the stack. In particular, the cells and interconnect layers do not need to be pressed together to establish an electric contact. As a consequence inkjet manufacturing could possibly help avoiding graduate loss of electric contact and thereby increase the stack lifetime. Further the SOC support layer can be omitted since the cells need not to be handled individually. This can significantly reduce the material usage and thereby decrease manufacturing cost.

METHODS AND EXPERIMENTAL

The electrolyte and electrode backbone is made of yttria-stabilized zirconia (YSZ). A detailed knowledge about ink rheology is required to make inks with sufficiently small, well-dispersed and suspended YSZ particles such that the particles do not agglomerate sediment and eventually clog the inkjet print head. Polyvinyl Pyrolydone (PVP) was identified as an effective dispersant for nano-YSZ particles in isopropanol/water solvent. The right amount of dispersant that matches the surface area of the particles was found and the solid loading was chosen to optimize the ink viscosity. A ratio of 20/80 wt% (or 25/75 vol%) isopropanol/water was found to optimize the surface tension relative to the print head requirement.

CONCLUSION

In conclusion, the possibility of reducing the manufacturing cost and increasing the robustness of solid oxide fuel cells by using 3D printing is explored in this project. Very thin electrolytes can already be produced using inkjet printing, and the print heads can use many different materials, making the process very versatile. If successful, 3D printing could drastically improve the SOC technology and thereby bring us one step closer to a green society.