Water steam electrolysis at intermediate temperature with Sn0.9In0.1P2O7 solid electrolyte

Prag, Carsten Brorson; Christensen, Erik; Li, Qingfeng; Bjerrum, Niels J.

Publication date:
2014

Citation (APA):
Prag, C. B., Christensen, E., Li, Q., & Bjerrum, N. J. (2014). *Water steam electrolysis at intermediate temperature with $Sn_{0.9}In_{0.1}P_2O_7$ solid electrolyte*. Poster session presented at 20th World Hydrogen Energy Conference 2014, Gwangju Metropolitan City, Korea, Republic of.

Water steam electrolysis at intermediate temperature with $Sn_{0.9}In_{0.1}P_2O_7$ solid electrolyte

Carsten B. Prag[a], Erik Christensen[a], Li Qingfeng[a], Niels J. Bjerrum[a]
[a] Department of Energy Conversion and Storage, Kemitorvet 207, Technical University of Denmark, DK-2800 Lyngby, Denmark

1. Introduction

$Sn_{0.9}In_{0.1}P_2O_7$ has gained some attention as a solid electrolyte for fuel cells in the intermediate temperature range (200 – 400 °C) due to its high proton conductivity[1]. In this work the focus was on developing and testing cells for steam electrolysis in said temperature range using $Sn_{0.9}In_{0.1}P_2O_7$ as electrolyte.

2. Experimental and procedures

$Sn_{0.9}In_{0.1}P_2O_7$, was synthesised using the acid/oxide route[1].
Electrolyte tablets were pressed (thickness: 0.6 mm) and assembled with anodes and cathodes. The electro-catalytic layers consisted of platinum black mixed with phosphate for the cathode, and iridium oxide mixed with the phosphate for the anode.
The test cell used stainless steel flow plates. The anode side flow plate was coated with tantalum metal to prevent corrosion. The measurements were done at 200 °C.
The electrolyte materials were characterised by XRD, FTIR and other methods, as well as by impedance spectroscopy on the cells. Electrolysis experiments were carried out to test performance under real electrolysis conditions.

Electrolyte: $Sn_{0.9}In_{0.1}P_2O_7$, 0.60 mm thick, 20 mm diameter
Anode: IrO_2, 4.45 mg/cm^2, Ta coated stainless steel felt
Cathode: Pt-black + Pt/C, 10.0 mg/cm^2 Pt, carbon paper

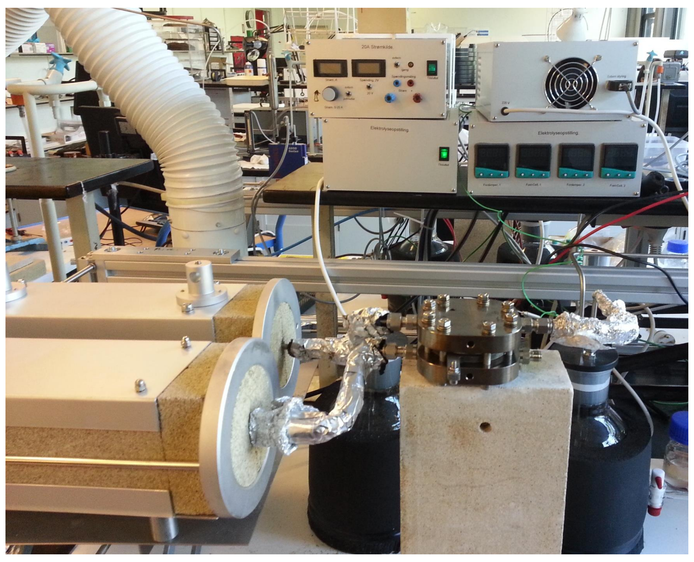

Figure 1 Experimental setup . The evaporator was connected to the assembled cell through the end plates and hydrogen was collected from the cathode.

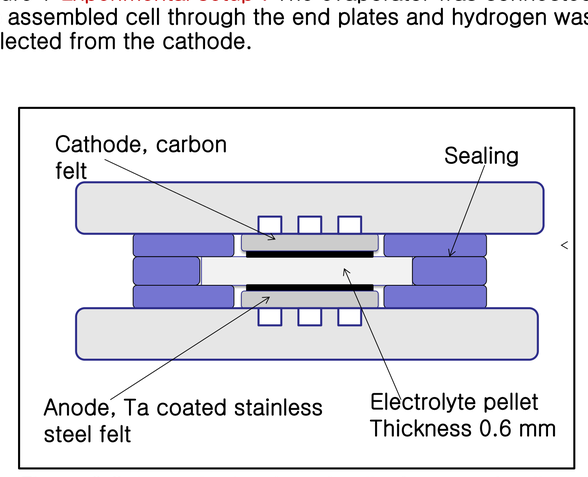

Figure 2 Schematic drawing of cell . A pressed pellet (ø = 20mm) of electrolyte material is placed between an anode and a cathode. (ø =13 mm).

3. Results and discussion

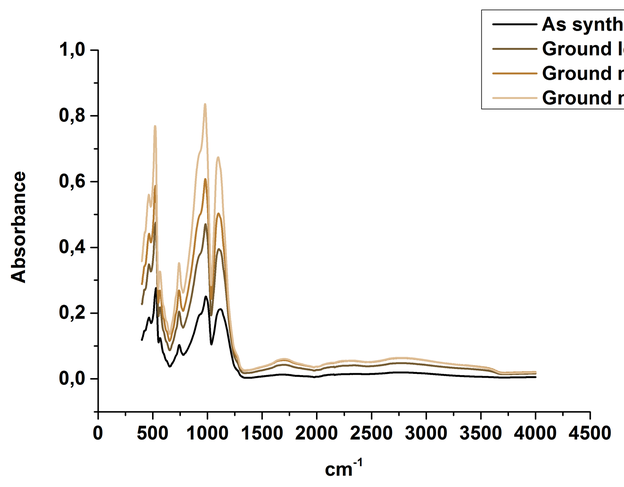

Figure 3: FTIR. Spectra of $Sn_{0.9}In_{0.1}P_2O_7$ material

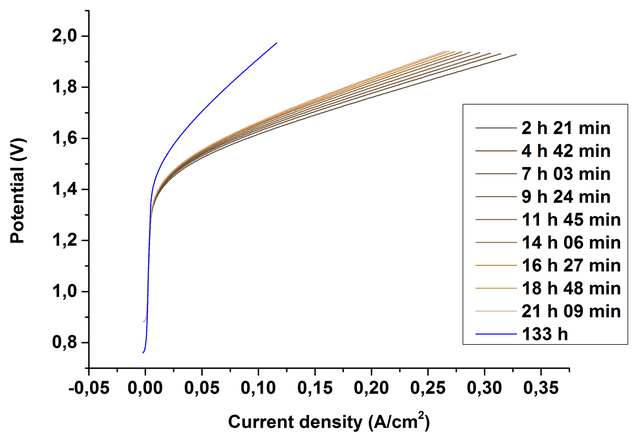

Figure 4: Polarisation curves. Polarisation at 200°C for the first 24 hours and after 113 hours

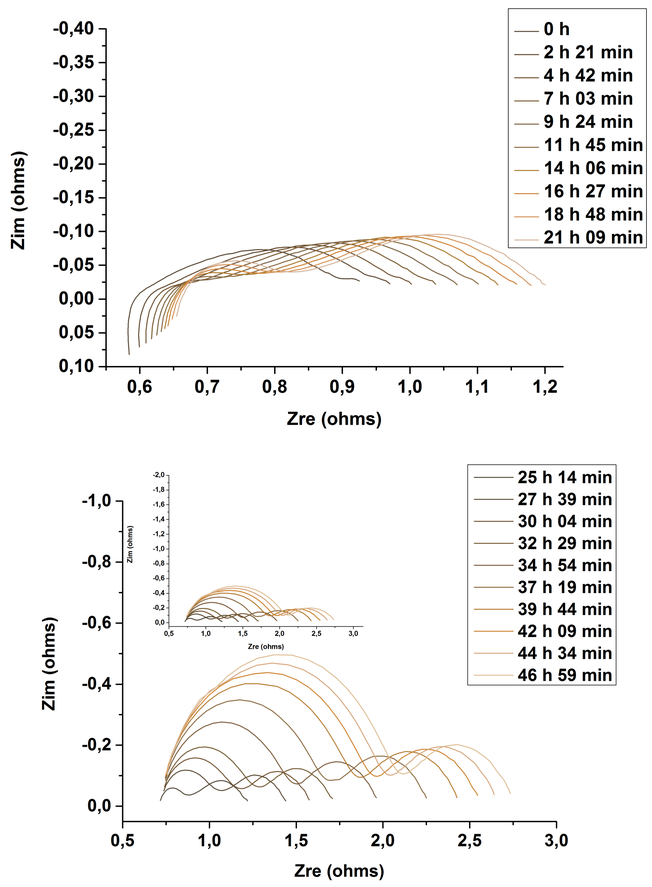

Figure 5: Impedance spectra. Impedance at 200°C a cell voltage of 1.8 V for the first 48 hours

FTIR spectroscopy was used as a fast tool for determining the presence of a proton conducting amorphous phase in the synthesised product. The broad band from 1500 cm^{-1} to 4000 cm^{-1} has been observed to stem from the amorphous phase. As can be seen from Figure 3 a thorough grinding of the synthesis product is important before evaluation.

Current densities up to 313 mA/cm^2 at 1.9 V were obtained at 200 °C for the initial run. After 113 hours this value had decreased to 97 mA/cm^2. The area specific resistance of the cell changed from 0,75 Ω·cm^2 to 1,16 Ω·cm^2 over the entire run. This small change indicates that degradation is mostly related to degradation, agglomeration or loss of electrocatalyst on the electrodes and not to conductivity loss in the electrolyte.

These results are encouraging as the electrodes are not in any way optimised and the thickness of the electrolyte is very high.

4. Conclusion

For the first time water splitting was reported on the basis of a solid phosphate electrolyte system. Electrolysis tests were run for up to 113 hours with current densities as high as 313 mA/cm^2 at 1.9 V. The electrolyte showed promising behaviour, and even though the electrodes seem to suffer over time the results are encouraging.

[1] Nagao, M.; Takeuchi, A.; Heo, P.; Hibino, T.; Sano, M. & Tomitab, A. (2006), *Electrochemical and Solid State Letters 9(3), A105--A109.*