ICE Abstract

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Plasma-sprayed non-PGM anodes and cathodes for alkaline water electrolysis

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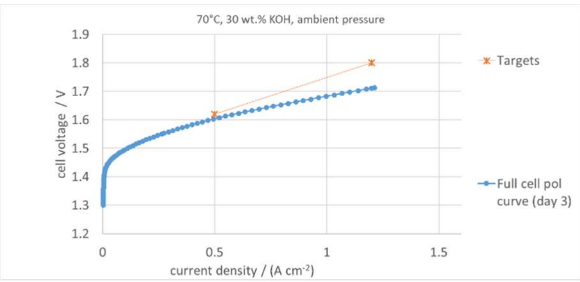
Low cost, PGM free, durable and efficient electrodes are needed for alkaline water electrolysis that can operate at high current density and with fluctuating power input such as from renewable energy sources. Production methods should be possible at large size and scale for electrolyser gigawatt rollout.

Within the project E^2NGEL DLR, KSG and McPhy address these challenges targeting for electrodes below -75 mV overpotential for the cathode and 220 mV overpotential for the anode at 0.5 A cm^{-2} as well as a full cell voltage of 1.8 V at 1.2 A cm^{-2}. The specific production method for electrode coatings is Atmospheric Plasma Spraying (APS) which is an industrially well-established process for metal coating. Various materials can be coated and by adjusting the process parameters the pore structure can be tuned.

Based on previous DLR coating developments, e.g. Raney nickel alloys by APS and vacuum plasma spraying (VPS) [1, 2] the method was further developed. New catalyst compositions were tested and process parameters were adjusted. Electrodes were coated on nickel wire mesh, nickel expanded metal or nickel punched hole sheet. After activation removing the leachable Al-rich phase the electrodes were tested at 70°C in 30 wt% KOH solution in a half-cell three electrodes setup and in a full cell of 8 cm^2. Phase distribution and structural analysis of the powders and the electrodes were performed by XRD, SEM and FIB-SEM (Focussed ion beam SEM).

For the cathode the original $Ni_xAl_yMo_z$ composition was varied. Higher Mo content was investigated expecting an improved catalysis and possibly amorphous phases. Lower Al content was investigated expecting a better long-term stability due to higher mechanical strength of the coating. Beyond these effects more properties of the coating are influenced by the composition. The desired low overpotential can be reached, due to the improved coating parameters and material composition. Furthermore, the coating layer thickness effect was investigated giving a trade-off between performance improvement for thicker coating vs. increased costs. To test mechanical stability of the layer an independent test was developed. For the anodes Ni_xFe_y coatings were APS sprayed and tested for the first time. To further adjust the porosity the addition of pore forming agents were studied. The desired overpotentials could be achieved due to the previously mentioned improvements. In full cell tests a very low cell voltage, exceeding state of the art, was demonstrated (Figure 1), as well as sufficient stability. The work continues with enlarged cells of 100cm^2 active area and at McPhy's 1000 cm^2 25 cell stack.



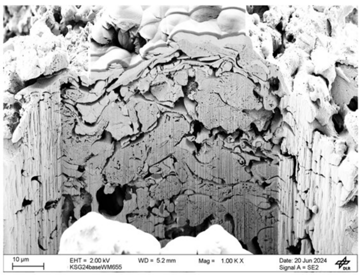


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Figure 1: left: 8cm^2 full cell polarisation curve with APS-sprayed electrodes (Anode and Cathode) Separator Zirfon® UTP 220 and project targets. Right: FIB-SEM result of electrode coating structure

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[2] F. Razmjooei, T. Liu, D. Aguiar Azevedo, E. Hadjixenophontos, R. Reissner, G. Schiller, S. Asif Ansar, K. A. Friedrich, NatureResearch (2020) 10:10948, https://doi.org/10.1038/s41598-020-67954-y

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