Institute of
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Improved electrodes and gas impurity investigations on alkaline electrolysers

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Motivation

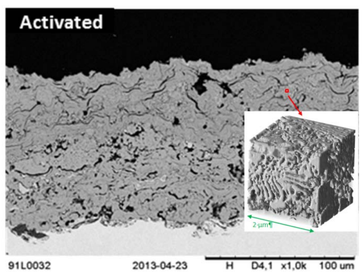
Alkaline water electrolysis for hydrogen production is a well-established technique but some technological issues regarding the coupling of alkaline water electrolysis and Renewable Energy Sources (RES) remain to be improved.

Targets:
- fluctuating power operation
- decrease of system costs
- higher operating pressure
- high efficiency, high current density
- ability to tolerate periods of non-operation

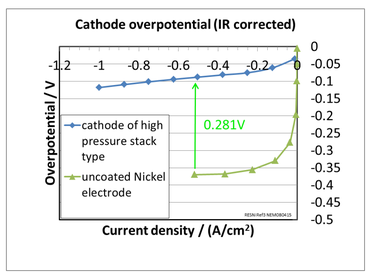
by
- electrodes with low cost coatings
- improved gas purity at low current density with new separator design

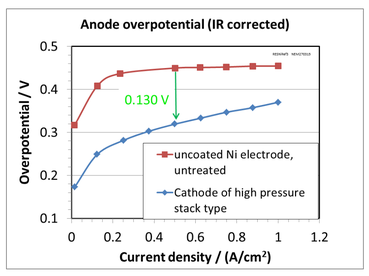
Methods and Results

Electrodes

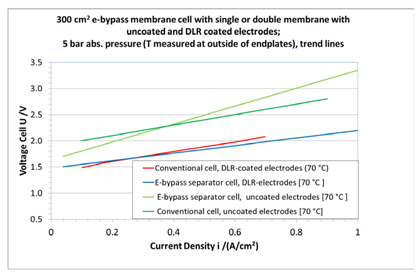


Cross-sectional SEM images of vacuum plasma sprayed Raney Ni hydrogen electrodes in the activated state. The cathode consists of two layers on the Ni substrate: the outer Al-Ni-Mo active surface layer and the inner Al-Ni bonding layer.
Inset: Three dimensional reconstruction of a tested cathode by focused ion beam tomography revealing internal porosity.
DTU



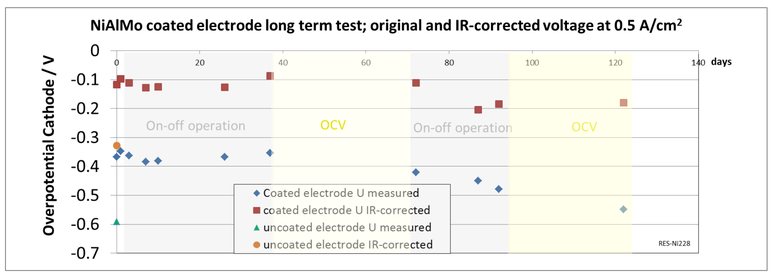


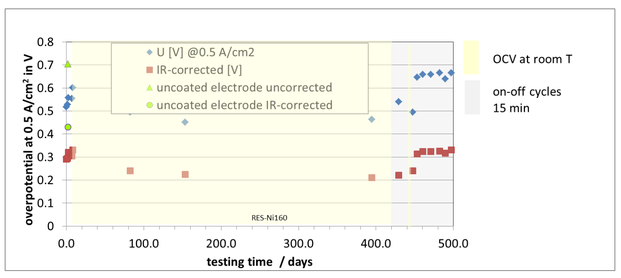
Comparison of coated and uncoated nickel expanded metal sheet electrodes. Half cell measurement of 4 cm² electrodes coated with NiAlMo and NiAl intermediate layer for the cathode (left) and NiAl for the anode (right), 70°C, 30 wt.% KOH



iV-curve of single cell electrolyser with 300 cm² electrodes equipped with e-bypass-separator or conventional separator and VPS-coated electrodes

Electrodes were plasma-spray coated with low cost Ni alloy coatings (AlNi and AlNiMo). After activation (Raney-Nickel) high porosity is achieved and electrodes show overpotential reduction in half cell and full cell tests. Long-term stability in on-off operation is demonstrated in half cell measurements. Futher improvement of efficiency in full cell operation is expected after upcoming experiments with new current density distribution measurement.

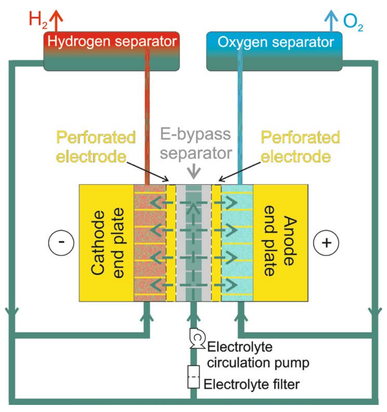


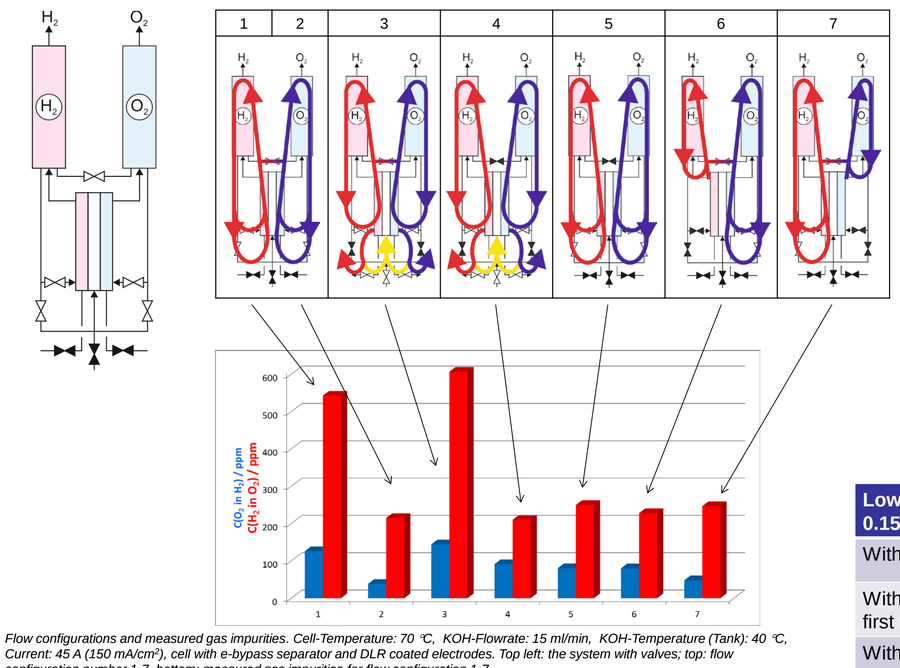


Long-term test of anode and cathode coated by VPS in intermittent operation, 0.5 A/cm², 70°C. Left cathode total time: 2930 h, 2780 on-off cycles (each 15 min).; Right: Operation time anode: 11.937 h (497 days), 3204 on-off cycles.

Gas Impurity

E-bypass separator (top); inset: SEM image of cross section (top); KOH flow concept in system using e-bypass separator (bottom). VITO





Flow configurations and measured gas impurities. Cell-Temperature: 70 °C, KOH-Flowrate: 15 ml/min, KOH-Temperature (Tank): 40 °C, Current: 45 A (150 mA/cm²), cell with e-bypass separator and DLR coated electrodes. Top left: the system with valves; top: flow configuration number 1-7, bottom: measured gas impurities for flow configuration 1-7.

Using a new cell concept with double layer separator (e-bypass separator) different flow concepts were tested. The primary pupose of this concept is to reduce the amount of H_2 impurities in O_2 and O_2 impurities in H_2 and at low current density due to diffusion of gases dissolved in KOH. It was found that there are further influences on gas quality by:
- single/double layer separator; permeability
- flows of KOH in cell e.g. due to differential pressure
- electrodes quality
- flows of KOH with microbubbles between gas separators → quality of gas separators

→ further measurements and simulations necessary to understand and improve gas quality even with single separator

Lowest gas impurities achieved at 0.150 A/cm², 70°C	O_2 in H_2 / ppm	H_2 in O_2 / ppm
With single separator, coated electrodes	77	980
With e-bypass separator, coated electrodes, first cell	63	250
With e-bypass separator, coated electrodes, last cell	38	215

Summary and Conclusions

- Electrodes with Raney-nickel-alloy coatings (low cost material) → overpotential reduction of 330 mV
- Electrodes show excellent stability: 1100 on-off cycles, 98% of initial efficiency retained
- Hydrogen in oxygen impurity reduced by ≥ factor of 4 due to e-bypass-separator (double layer separator)
- Cell can be operated at higher pressure and/or lower current density before reaching the limiting gas concentration
- Gas impurity in an electrolyser depends on many more factors than only which type of separator is used
- For further improvement of electrolysers study of internal problems using current density distribution measurements has been started

References

Further information:
Project RESelyser
www.reselyser.eu

Final report RESelyser
www.reselyser.eu/14.html

Poster P-94, J.Mitzel et al.

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DLR Deutsches Zentrum für Luft- und Raumfahrt