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**Development of novel High Temperature and Pressure Alkaline Electrolysis Cells (HTP-AEC)**

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### Introduction

**Background**
- A HTP-AEC with gas diffusion electrodes (metal foams) and an aqueous KOH electrolyte immobilized in a mesoporous ceramic matrix structure has been developed at DTU Energy.
- Very high current density and performance has been demonstrated with shirt button sized cells: record data from earlier work [1]:
  - 1.75 A/cm² at 1.75 V with 
  - s₂ = 85% (200°C, 20 bar) [3]

**Motivation**
- High temperatures (200°C) increase the activity of the electrodes and the conductivity of the electrolyte significantly.
- A cell that allows for high efficiency and current density simultaneously using non-noble metals.

**Challenges**
- Corrosion issues at the oxygen electrode. Identification of more stable materials, which also show sufficiently high catalytic activity towards the oxygen evolution reaction.
- Processing of cell layers with optimized microstructure using a low cost & scalable processing method.

### The experiments

**Electrode materials for the oxygen electrode**
- Electrode materials (electrocatalysts) based on La, Ni and Fe for the oxygen evolution reaction (OER)
- Electrode materials for the oxygen electrode
- The experiments
- The electrochemical activity of the materials has been tested at room temperature and pressure conditions.

**Three-electrode setup for electrochemical characterization**
- Working electrode (pressed bars, Au current collector)
- Counter electrode (Pt mesh)
- Reference electrode (RHE from Gaskatel)

### Results – chemical stability

LaNi₀.₆Fe₀.₄O₃ pellet surface before and after ~20 h electrochemical testing.

**XRD patterns**
- 

**ICP analysis of supernatants from the KOH solution used for the chemical stability testing.**
- Any dissolution is not accounted for.

### The cell concept

**Motivation**
- The mesoporous electrolyte matrix contains the KOH electrolyte. The porous electrodes will allow some infiltration of the electrolyte into the electrode to increase the surface area where the electrochemical reactions take place.

**Overview**
- Successful fabrication and electrochemical characterization of up-scaled cells (5 x 5 cm²) with microstructurally optimized oxygen electrode is the expected outcome of the project.

### Results - Electrochemical activity towards the OER

**Comparison of the 2nd set of chronopotentiostatic tests performed at 10 mA/cm².** LaNi₀.₆Fe₀.₄O₃ could not be sintered dense without decomposition so it is a multiphase of mainly LaNiO₃, NiO and La₂NiO₄.

The calculated Tafel fit parameters (β = a + b log(I)) from the tafel plot together with the overpotential, η, at 10 mA/cm². The state-of-the-art, IrOₓ, and two of the best performing non-noble oxygen evolution catalysts are also included as benchmarking.

### Outook

**Processing of porous oxygen electrodes**
- Based on the electrochemical screening LaNi₀.₆Fe₀.₄O₃ is going to be used as oxygen evolution electrocatalyst. The microstructure of the oxygen electrode is going to be optimized using the processing method screen-printing. An electrode with a bimodal porosity distribution is envisioned to allow for electrolyte infiltration (~10-100 µm pore sizes) and gas diffusion (2-10 µm pore sizes) of evolved oxygen.

Successful fabrication and electrochemical characterization of up-scaled cells (5 x 5 cm²) with the microstructurally optimized oxygen electrode is the expected outcome of the project.

### References