Modeling And Optimization Of 3D Electroformed Ni Electrodes For Alkaline Electrolysis In COMSOL

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Abstract

Electroformed Ni-based 3D electrodes (NiE3) offer a novel approach to enhancing alkaline electrolysis performance by increasing surface area and active sites, leading to intensified electrolysis reactions and improved efficiency. However, inefficient bubble release from the produced gases (H2 and O2) can significantly contribute to ohmic resistance and elevated cell potential, reducing overall system efficiency. Optimizing electrode architecture, mass transport dynamics, and gas evolution mechanisms is crucial for mitigating these effects and improving operational performance.

To achieve this, we developed a 3D computational model in COMSOL Multiphysics that simulates two-phase gas-fluid interactions, electrochemical reactions, and mass transport phenomena within a zero-gap electrolysis cell. Using electrochemistry simulations and Euler-Euler CFD modelling, we analyzed gas distribution and bubble dynamics. These insights informed design optimizations that mitigate bubble-induced resistance, leading to improved electrochemical efficiency and lower energy losses.

Through simulation-driven electrode innovation, this work highlights the potential of NiE3 technology in advancing sustainable energy solutions by improving energy efficiency and scalability for large-scale hydrogen production.

Figures used in the abstract

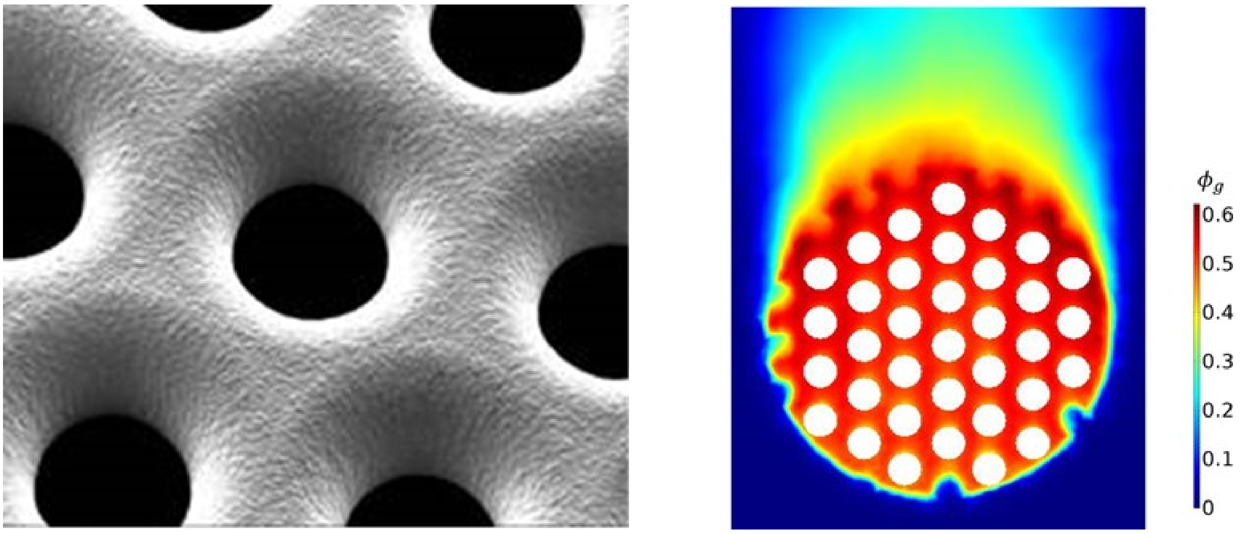

Figure 1 : Visualization of a 3D porous electrode (left) and the corresponding simulated hydrogen gas fraction distribution (right), with color gradients representing varying H_2 concentrations.