# Microstructural Engineering Ni-Based Alloy Surfaces for Enhanced OER Performance

Luka Suhadolnik, Črtomir Donik, Blaž Tomc, Mejrema Nuhanović, Martin Šala, Marjan Bele, Matjaž Finšgar, Matjaž Godec, Nejc Hodnik

*National Institute of Chemistry, Hajdrihova 19, SI-1000 Ljubljana, Slovenia; Institute of Metals and Technology, Lepi pot 11, SI-1000 Ljubljana, Slovenia; Faculty of Chemistry and Chemical Engineering, University of Maribor, Smetanova 17, SI-2000 Maribor, Slovenia; University of Nova Gorica, Vipavska 13, SI-5000 Nova Gorica, Slovenia.,*

*E-mail: nejc.hodnik@ki.si*

Efficient and affordable electrocatalysts are essential for advancing alkaline water electrolysis as a foundation of green hydrogen production. Nickel-based electrocatalysts represent the state-of-the-art, offering a promising platform due to their tunable surface properties and industrial scalability [1].

We demonstrate that sequential nitridation and anodic oxidation of Inconel 625, a commercial Ni-based alloy, induces the formation of NiFe-rich, Cr-depleted regions at grain boundaries and microcracks that enhance the electrochemical surface area and boost OER performance. The resulting nanostructured surface, with an optimized Ni/Fe ratio (~8:1), outperforms both the untreated alloy and benchmark $IrO_2$ electrodes. Morphological and compositional changes were tracked using advanced electrochemical techniques, namely identical-location SEM/EDS [2], EBSD, and also supported by XPS and ToF-SIMS. Cr segregation and δ-phase precipitation were found to drive intergranular corrosion during activation, while fine-grained regions exhibited greater porosity and catalytic activity.

These findings highlight the potential of commercial nickel-based alloys as scalable, cost-effective electrocatalysts for alkaline water electrolysis. This work demonstrates how targeted microstructural engineering and electrochemical treatments can repurpose industrial alloys for sustainable hydrogen technologies.

1. Magnier, L., Cossard, G., Martin, V., Pascal, C., Roche, V., Sibert, E., Shchedrina, I., Bousquet, R., Parry, V., Chatenet, M., Nat. Mater., 2024, 23, 252–261.
2. Hodnik, N., Cherevko, S., Curr. Opin. Electrochem., 2019, 15, 63–70.