Nickel electrodes in energy conversion reactions: The determination of the electrochemically active surface area and its influence on the activity of structured Ni electrodes produced by additive manufacturing

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Ni electrodes are widely implemented in electrocatalysis, most notably in alkaline electrolysis. Additively manufactured (AM) nickel electrodes offer a great potential as an efficient solution for the fabrication of structured high surface area electrodes with complex geometries. This would be particularly important for reactions involving a gas phase, but also in generally furthering the understanding of mass transport effects at complex interfaces. The accurate determination of the electrochemical active surface area (ECSA) is a key step in the evaluation of the intrinsic electrocatalytic activity of such complex electrodes. In this work[1], we fabricated six Ni electrodes with different macroscopic geometries using laser powder bed fusion of metals (PBF-LB/M). X-ray photon spectroscopy (XPS) and a non-contact optical profilometer (NCOP) were used to investigate the composition and surface morphology of the electrodes. The ECSA was determined by different approaches: linear and non-linear allometric fitting of the double layer capacitance from voltammetric experiments; the integration of the $Ni^{2+/3+}$ transition; assessing double layer capacitance determined from electrochemical impedance spectroscopy (EIS) at open circuit potential (OCP) and the adsorption capacitance for the oxygen evolution reaction (OER) intermediates. Comparing these methods, large deviations in the resulting ECSAs were found, motivating a comprehensive discussion. In addition, four different reactions were investigated: the ferri-ferrocyanide redox system, hydrogen evolution, ethanol electrooxidation, oxygen evolution and nitrogen reduction reaction. Based on the results, it will be shown that increasing the surface area of the electrode has different effects depending on the type of reaction and the applied electrode architecture. The obtained results demonstrate the potential of AM to tailor electrode performance by altering electrode geometry and underline the importance of the ECSA determination for the comparison of the electrocatalytic activity in different electrodes.

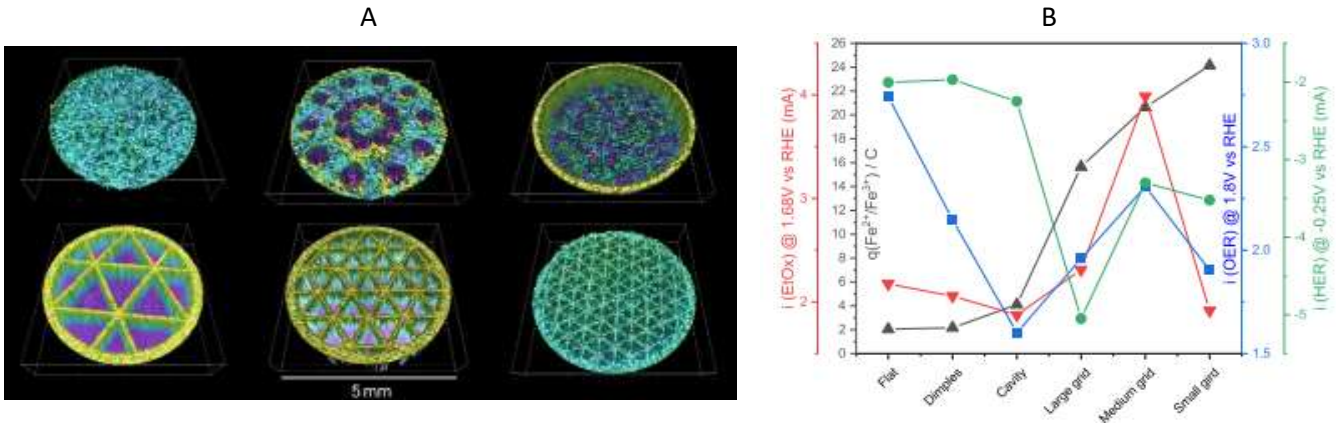

Figure 1. (A) Images taken by NCOP (B) Activities of the manufactured electrodes towards the $Fe^{2+/3+}$ redox, oxygen evolution, hydrogen evolution, and ethanol oxidation reactions

Acknowledgement: A.R.K, R.M-H, M.U.A & V.˘ C. acknowledge the Max Planck Institute for Chemical Energy Conversion for funding part of this work. The authors thank Ulrich Hagemann and the International Center for Analytics on the Nanoscale (ICAN) for his help with the XPS experiment and analysis.

References

1. R. Martínez-Hincapíe, J. Wegner, M.U. Anwar, A Raza-Khan, S. Franzka, S. Kleszczynski, V. Čolić, *Electrochimica Acta* **476** (2024) 143663 https://doi.org/10.1016/j.electacta.2023.143663