

Enhanced oxygen evolution from (de-)alloyed nickel thin film electrodes

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Water electrolysis from renewable electricity may enable the widespread use of hydrogen as a high energy density carrier with no point-of-use emissions. Production of hydrogen by water electrolysis has already been intensively studied, but efficiency of electrochemical cells still needs to be improved before they can be used on larger scales. The electrochemical performance of the electrodes itself is currently still one of the limiting factors. Improvements in efficiency can be obtained by increasing the rate of electron transfer between water and the electrode, or by improving mass transport of reactants and gaseous products. The objective of this work consists in improving the mass transfer aspect by tailoring the electrode morphology in order to favor bubble detachment. Indeed, inefficient gas bubble detachment from the electrode surface results in higher overpotentials due to blockage of active sites. In this respect, earlier reports have shown how optimal synthesis conditions for DSA-type anodes leading to mud-crack type surfaces showed enhanced bubble detachment for the oxygen evolution reaction [1].

In the current contribution, we use (de-)alloyed nickel thin film electrodes to evaluate performance enhancements resulting from improved bubble detachment at the electrode surface. Nickel is a primary candidate material for the oxygen evolution reaction (OER) due to its low cost, relative abundance, high activity and its long-term stability in alkaline solutions. Our nanostructured nickel electrodes were obtained by first magnetron co-sputtering of Al-Ni alloys from pure Ni and Al targets, followed by selective Al leaching in concentrated hydroxide solutions. The use of such de-alloyed thin films was shown to allow to distinguish between improvements resulting from changes of the specific surface area and from the morphology. Cyclic voltammetry on this new type of de-alloyed electrodes shows a significant decrease of the overpotential for the oxygen evolution reaction as compared with pure Ni electrodes, a drop of 140 mV at 10 mA/cm² being obtained in the best case. The aim of this study will then be to discuss on the one hand the morphology and microstructure of these de-alloyed Ni electrodes as a function of their processing conditions combining ICP-OES, XRD, ECSA and AFM analysis, and on the other hand to demonstrate how these structural features have lead to the observed enhanced electrochemical performance for the OER.

[1] A.R. Zeradjanin, A.A. Topalov, Q. Van Overmeere, S. Cherevko, X. Chen, E. Ventosa, W. Schuhmann, K.J.J. Mayrhofer, RSC Adv. 4 (2014) 9579.