Effect of morphology and mechanical stability of Nanometric Platinum layer on Nickel foam for hydrogen evolution reaction

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Supplementary Material

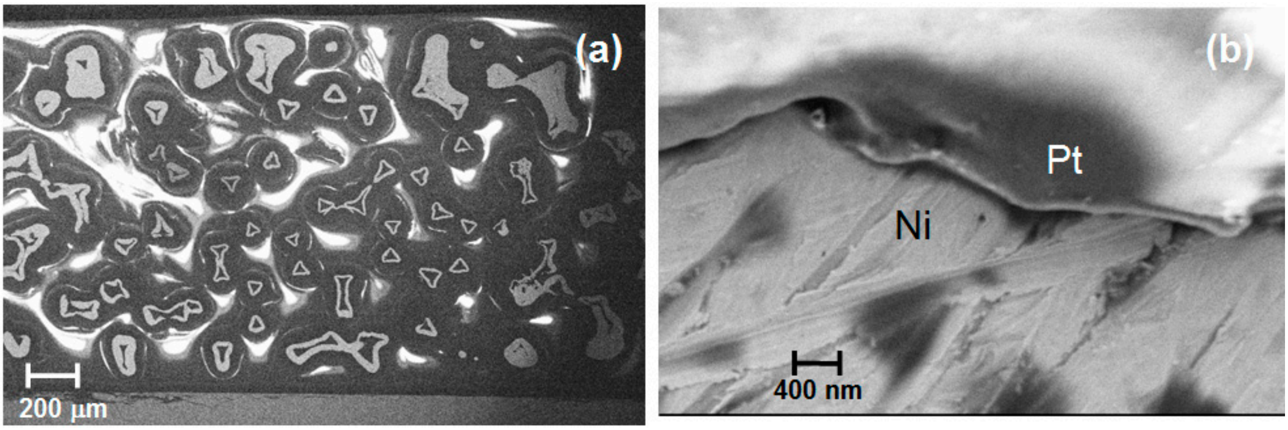

Figure S1: (a) Cross sectional SEM micrograph of the Ni foam after 8 min Pt deposition. **(b)** SEM image at higher resolution, showing the Pt layer on the Ni surface.

Figure S1 (a) shows the cross sectional image obtained by SEM analysis. The sample has been prepared by encapsulation of the foam into an epoxydic resin, cutting and polishing. The total electrode thickness is 1.6 mm. The white and very dark regions are the glue, while the grey structures are the Ni foam struts. Ni foam struts are hollow, with triangular section. Figure S1 (b) is a higher magnification micrograph showing the Pt film on top of the Ni surface. The thickness is about 40 nm. The presence of Pt has been confirmed by EDX analyses.

In a cross sectional image of total area A we can randomly find areas occupied by Ni struts. The ratio between the sum of the Ni areas (A_{Ni}) and the total image area A is the Ni fraction in 2D, $f_{2D}(Ni)$. This can be converted into the volume fraction f_{3D}, as

$$f_{3D} = \left(f_{2D}\right)^{3/2} \tag{1}$$

We measured the $f_{2D}(Ni)$ in several SEM cross sectional micrographs by using the Gatan software tool DigitalMicrograph® that allows to count and evaluate the area and perimeter of the objects into a calibrated image. In this way we obtained the volume fraction occupied by Ni in the foam. The measured value, averaged over 6 different cross sections is 4.3%, in agreement with the value of 5% given by the supplier (porosity 95%). The volume fraction occupied by platinum can be evaluated by using a similar approach. For each Ni region, in a 2D image the area covered by Pt is given by the thickness of the Pt layer, t, multiplied by the external perimeter of the struts, L_{Ni}. Assuming the thickness of deposited platinum is constant (as expected with the optimized conditions using stirring and IPA), the total Pt area fraction is $f_{2D}(Pt)$ is:

$$f_{2D}(Pt) = \frac{\sum L_{Ni}}{A} t \tag{2}$$

Again by assuming that $f_{3D} = (f_{2D})^{3/2}$, we can calculate the Pt volume fraction. The amount of Pt per electrode can be calculated as:

$$Pt\left[\frac{mg}{cm^2_{electrode}}\right] = f_{3D}(Pt) * V_{electrode} * \rho_{Pt} \qquad (3)$$

with ρ_{Pt} = 21.45 g×cm^{-3} the Pt density, and $V_{electrode}$, the volume of a an electrode with area 1 cm^2, i.e. $V_{electrode}$ = (1x1x0.16) cm^3.

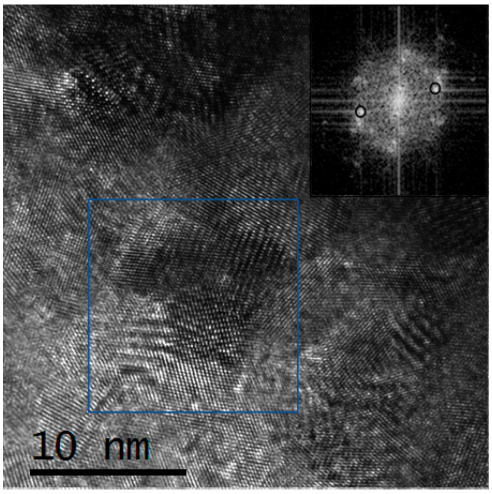

Figure S2: TEM micrograph of a Pt grain deposited on nickel by spontaneous galvanic displacement, after 1 min deposition. Moire fringes indicate the presence of two different crystalline patterns and the FFT in the inset shows the presence of spots (marked with black circles) corresponding to a plane distance of 2.2 A, which is the value of (111) planes of Pt. The other spots are the pattern of NiO.

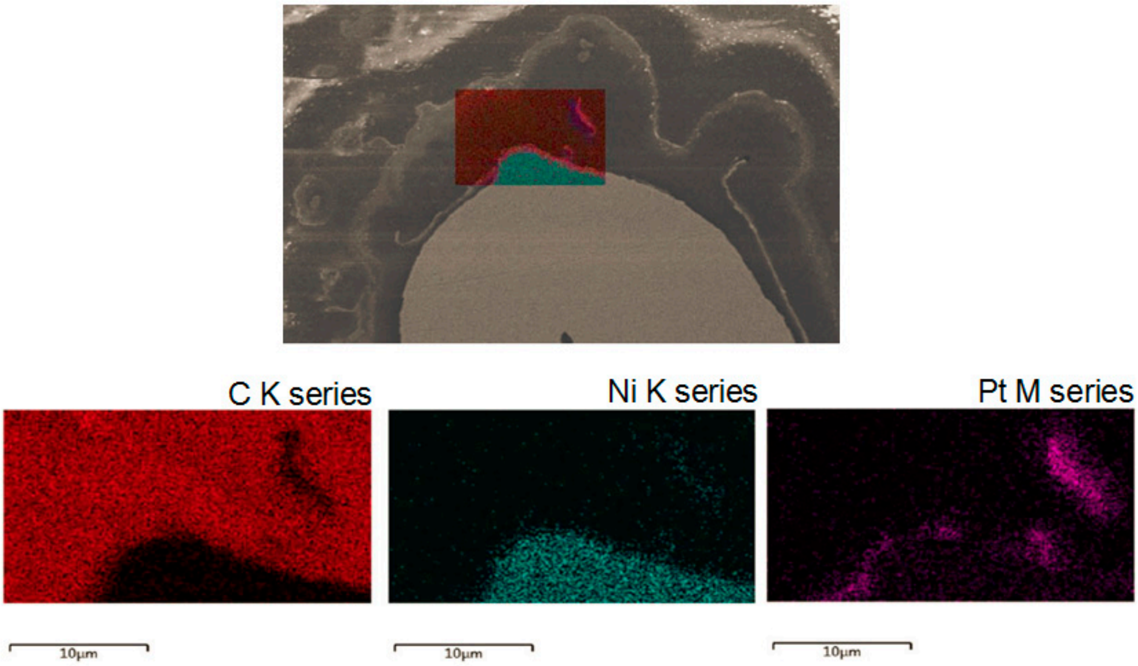

Figure S3: Cross section SEM image of a strut of Ni foam A after Pt deposition for 16 min. The elemental analysis shown in colour maps indicate the presence of a Pt film at the Ni surface, partially detached in some regions.

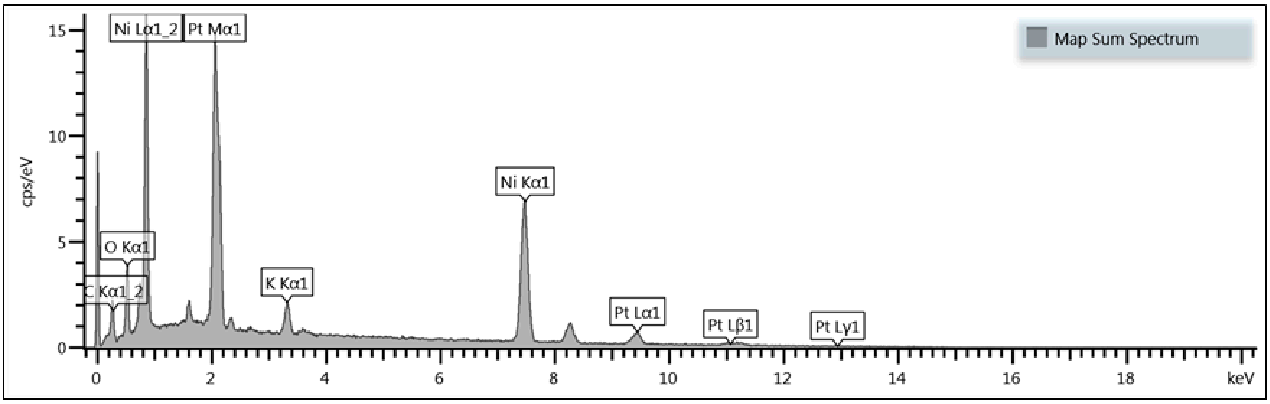

Figure S4. EDX spectrum acquired on the external surface of the Ni foam (sample A), after Pt deposition for 8 min.