Influence of nanoporous anodic alumina barrier layer thinning on electropulsed deposition Ni nanorods for energy storage applications

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Abstract

In the present climatic emergence situation, the reduction of unsustainable resources stimulates great research efforts on renewable energy. One of the key technologies is energy storage where supercapacitors (SCs) provide a means to store energy with quick charge/discharge rates and large cycle number. To improve SCs performance, nanostructuring of the electrodes offers a larger surface area for charges to store [1]. Nanoporous anodic alumina (NAA) can be used as a template for the preparation of nanostructured electrodes by the application of electrodeposition of metals within the pores [2]. This is only possible when a metallic contact at the bottom of the pore is provided so that metallic ions in soultion can be reduced and deposited. Such metallic contact is achieved following the procedure in ref. [3] where a final etching step to remove the residual barrier layer is crucial to provide uniform contact through all the sample.

In this work, we study the influence of the time extent of this final etchig step (t_E) on the uniformity and morphology of deposited Ni nanorods. NAA templates were synthesized with the two-step anodization procedure followed by a third step reanodization for in-situ thinning of the barrier layer. Subsequently, the final etching step with 5 wt% phosphoric acid solution at 35 ℃ is applied for a time extent t_E.

Fig. 1 shows deposited Ni nanorods for two samples with different final ethching times. Fig. 1(a) corresponds the t_E=10 min. while Fig. 1(b) corresponds to t_E=15 min. For the shorter etching time a large dispersion of the Ni nanorods length, with values ranging between 200 nm and 1 µm, can be observed. Instead, the longer etching time shows a more uniform distribution of lengths around 250 nm. Shorter etching times lead to an even bigger length dispersion because of an incomplete barrier layer thinning. On the other hand, longer pore widening times result in an excessive dissolution of the pore walls. From these results we can conclude that the optimum time for the final etching is about 15 minutes as it gives homogenous contact throughout the sample for Ni deposition. These obtained metallic nickel nanorods by electropulsed deposition can be used as electrodes for the application of high-performance SCs.

References

[1] Liang Kun, Lei Li, and Yang Yang, ACS Energy Letters 2.2 (2017): 373-390.
[2] Santos Abel, Lukas Vojkuvka, María Alba, Victor S. Balderrama, Josep Ferré-Borrull, Josep Pallares, and Lluís F. Marsal, Physica Status Solidi (a) 209, no. 10 (2012): 2045-2048.
[3] Nielsch, Kornelius, Frank Müller, Li AP, and Ulrich Gösele, Advanced Materials 12, no. 8 (2000): 582-586.

Figures

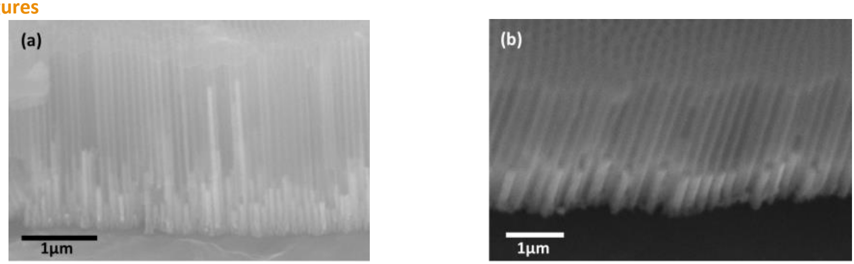

Figure 1: Ni nanopillars obtained by pulsed electrodeposition in NAA. a) nanopillars obtained for barrier-layer etching time t_E = 10 min. b) nanopillars obtained for t_E = 15 min.