Electronic Supplementary Material (ESI) for RSC Advances.

Hierarchical porous $NiCo_2O_4$ nanograss arrays grown on Ni foam as electrode material for high-performance supercapacitors

Zhenyu Wang, Yuefei Zhang, * Yonghe Li, Haoyu Fu

Institute of Microstructure and Property of Advanced Materials, Beijing University of Technology, Beijing, 100022, P. R. China
E-mail: yfzhang@bjut.edu.cn

The calculation of mass loading

The ICP analysis was used to calculate the mass loading on the Ni foam. In a typical procedure, the $NiCo_2O_4$ combined with Ni foam obtained after the synthesis reaction was dissolved in 25 ml of concentrated nitric acid, and diluted with deionized water to 250 ml. Then the samples were analyzed by ICP-AES. In the ICP-AES analysis, the content of cobalt was tested. As the content of Cobalt in the $NiCo_2O_4$ is constant, the mass loading of $NiCo_2O_4$ on the Ni foam could be calculated through the Equation (1). The results were shown in the table S1.

$$M=a\times 250\ (ml) \times M_{NiCo2O4}/1000\ (ml) \times 2M_{Co} \qquad \text{Equation (1)}$$

Where M (mg) represents the mass loading of $NiCo_2O_4$, a (ppm) represents the content of cobalt, $M_{NiCo2O4}$ represents the molar mass of $NiCo_2O_4$, M_{Co} represents the molar mass of cobalt.

Table S1. The Cobalt content of the samples.

No	Content of cobalt (ppm)	Mass loading (mg)
1	0	0
2	4.3	2.20
3	4.2	2.14
4	4.3	2.20
5	4.3	2.20
6	4.4	2.25
Average	4.3	2.20

To eliminate the influence of Nickel foam that may import the Cobalt into the solution, we have tested the pure Nickel foam (No 1) to detect the content of Cobalt. Fortunately, the content of Cobalt in Nickel foam is 0, showing that the Nickel foam did not import the impurity. Through the calculation, we got that the mass loading of $NiCo_2O_4$ was 2.2 mg.

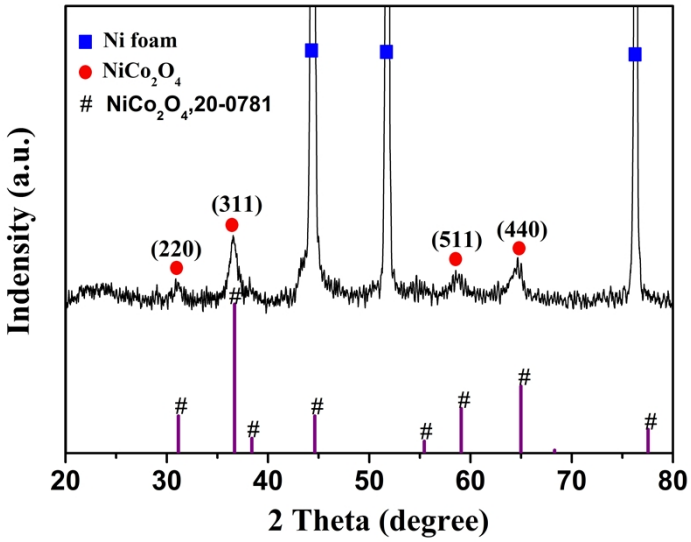

Fig.S1. XRD pattern of hierarchical porous $NiCo_2O_4$ nanograss arrays grown on Ni foam.

Fig.S1 shows the typical XRD spectrum of the product. The diffraction peaks except for the three typical peaks originating from the Ni foam can be indexed to spinel $NiCo_2O_4$ phase (JCPDS no 20-0781), which demonstrate the material obtained after the thermal treatment was $NiCo_2O_4$.

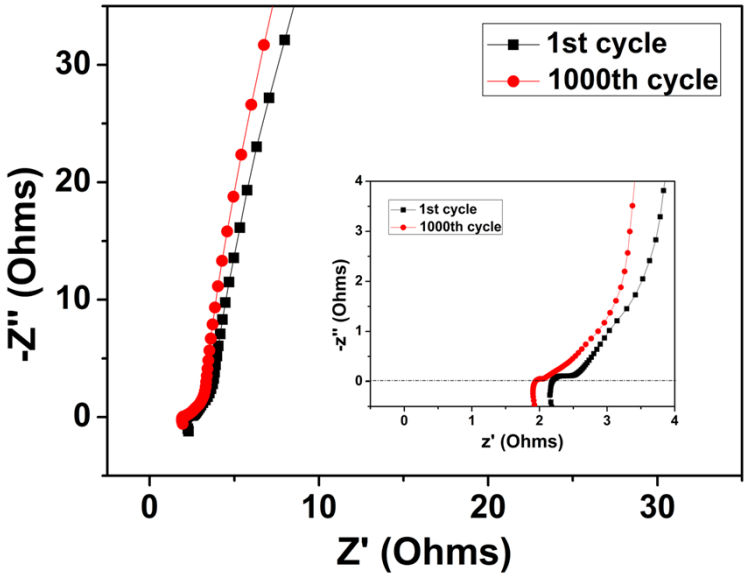

Fig.S2 EIS spectrum 1st and 1000th cycle of the $NiCo_2O_4$ electrode. The inset is an enlarged curve of the high frequency region.

To explore the evidence for the capacitance increase in the first 1000 cycles, the EIS analysis was adopted. Fig. S2 shows the EIS spectrum of hierarchical porous $NiCo_2O_4$ nanograss arrays on Ni foam electrode obtained after 1st and 1000th cycle. Both the impedance spectra are almost similar in form with a quasi-semicircle at high-frequency and a linear component at the low-frequency. The internal resistance (R_b), which includes the total resistances of the ionic resistance of electrolyte, intrinsic resistance of active materials and contact resistance at the active material/current collector interface, can be obtained from the intercept of the plots on real axis.[1] As can be seen from the inset, the R_b of 1000th cycle is 1.8, smaller than 2.2 of the 1st cycle, which agrees well with the result shown in the long-term stability test, indicating the enhancement of the ion diffusion and effective electron transfer in the electrode reaction. In addition, in the low frequency region, the slope of the impedance plot of the 1000th cycle shows more vertical than the 1st cycle, indicating

the enhancement of electrochemical capacitance the $NiCo_2O_4$ nanograss/Ni foam electrode in the KOH aqueous solution through the activation after 1000 cycles.[2]

References

1. M. C. Liu, L. B. Kong, C. Lu, X. M. Li, Y. C. Luo and L. Kang, *ACS Appl Mater Interfaces*, 2012, **4**, 4631.
2. C. Yuan, J. Li, L. Hou, X. Zhang, L. Shen and X. W. D. Lou, *Adv. Funct. Mater.,* 2012, **22**, 4592.