Int. J. Electrochem. Sci., 8 **(2013)** 6900 - 6904

International Journal of
ELECTROCHEMICAL
SCIENCE
www.electrochemsci.org

Short Communication

Sythesis of High Voltage Supercapacitor and Electrochemical Performance

Kai Wang[1], *Liwei Li*[1], *Tiezhu Zhang*[2]

[1] School of Automation Engineering, Qingdao University Shandong Province, Qingdao, 266071, China
[2] Vehicle Electronic Technology Research Institute, Qingdao University Shandong Province, Qingdao, 266071, China
[*]E-mail: wkwj888@163.com

Received: 29 January 2013 / *Accepted:* 11 March 2013 / *Published:* 1 May 2013

The work unit for 100 V voltage of the hybrid supercapacitor is synthesized by using Ta/Ta_2O_5 as the anode, activated carbon as the cathode. Compared with the usual electrochemical capacitor working voltage, the capacitance had improved. The electrochemical performance shows that it has high energy storage density and rapid charging and discharging ability, electrochemical spectrum impedance (EIS) analysis shows that it has good impedance characteristics and the frequency characteristics.

Keywords: high voltage, active carbon, electrochemical

1. INTRODUCTION

In recent years, electrochemical supercapacitors (ES) or ultracapacitors have attracted significant attention, mainly due to their high power density, long cycle life, and bridging function for the power/energy gap between traditional dielectric capacitors (which have high power output) and batteries/fuel cells (which have high energy storage) [1-3]. Transition metal oxides are a class of important mineral materials that have drawn extensive research attention as electrode materials. Transition metal oxides such as ruthenium oxide, manganese oxide, cobalt oxide, and nickel oxide are qualified to be electrode materials for electrochemical capacitor [4-6]. Some of them, such as ruthenium oxide and iridium oxide, exhibit excellent properties for use as pseudo-capacitive electrode materials [7-9]. Among these materials, the hybrid supercapacitor attracts particular interest due to its high voltage [10-15]. The lower voltage limits its applications.

In this work, the hybrid supercapacitor is synthesized by using Ta/Ta_2O_5 as the anode, activated carbon as the cathode. The supercapacitive behavior was investigated in 3M KOH electrolyte. The cycle performance of the hybrid supercapacitor has been investigated.

2. EXPERIMENTAL

2.1 Materials preparation

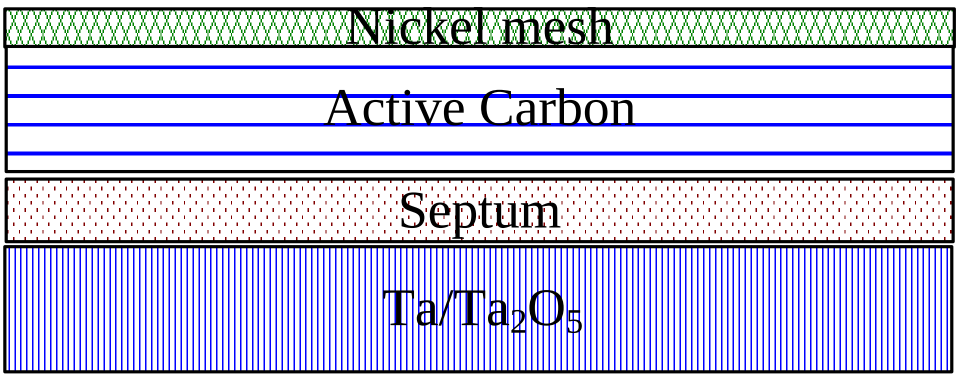

Figure 1. The structure of hybrid supercapacitor

The structure of hybrid supercapacitor is shown in Fig. 1. Using Ta/Ta_2O_5 as the anode, activated carbon as the cathode, we developed a work unit for 100 V voltage of the hybrid supercapacitor. Ta/Ta_2O_5 is made from high purity of porous metal tantalum powder as electrode materials, pressing forming, through high heat sintering, using electric chemical method to control the reaction time in the radius of 15 mm and the thickness of 0.1 mm of tantalum anode surface to form the thickness of 0.01 mm a layer of Ta_2O_5 film. The layer of the film is able to withstand a certain voltage, and the voltage and dielectric film layer thickness. In this paper we design the voltage for 100 V.

2.2 Electrochemical measurements

The working electrode was prepared by 85 wt% of the active material (Active carbon), 10 wt% of conducting agent (carbon black), and 5 wt% of binder (polyvinylidene difluride, PVDF). This mixture was pressed onto the glassy carbon electrode (Aida Hengsheng Technology co. td, Tianjin, China) and then dried at 60 °C. The electrolyte used was 3 M KOH aqueous solution. The capacitive performance of the sample was tested on the CHI660 electrochemical workstation (CHI, USA) with cyclic voltammetry and chronopotentiometry functions using Two-electrode system. Experiments were carried out at room temperature.

3. RESULTS AND DISCUSSION

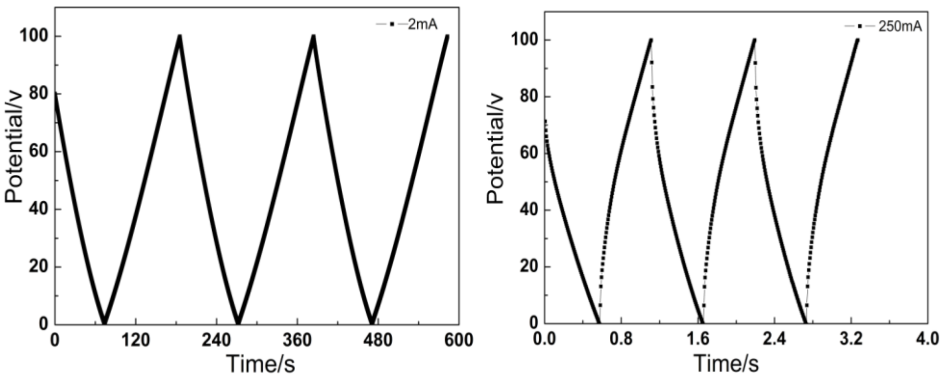

Figure 2. Galvanostatic charge-discharge curves at 2mA, 250mA

Fig.2 shows the galvanostatic charge-discharge curves at at various current rates (2mA, 250mA). It is very clear that there is a distinct plateau in every curve, corresponding to the Faradaic discharging process. The specific capacitance can be calculated according to the equation: $C_m = I*\Delta t/(m*\Delta U)$. Thus, the specific capacitance is calculated to be 2.3, and 2.1 mF at discharge current of 2 and 250 mA, respectively. The decrease in specific capacitance is attributed to the hybrid supercapacitor that cannot sustain the redox reactions completely at a higher current.

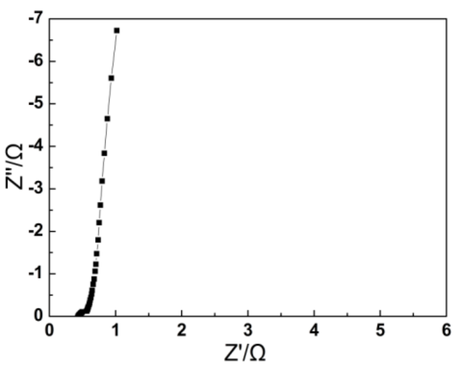

Figure 3. Impedance characteristic curve of the supercapacitor

Fig. 3 shows the impedance characteristic curve of the supercapacitor. AC impedance test frequency range is 0.1 Hz ~ 100 KHz, the amplitude is 5 mV and initial voltage is 0 V. Z' is internal resistance of the hybrid capacitor, Z'' is the capacitive reactance of the hybrid capacitor. From the Fig. 3 we can see that high frequency area appears an obvious half arc, which suggests that there is a charge transfer resistance and the Warburg resistance. The high frequency half arc is small, which shows that the electrode/electrolyte interface charge transfer resistance is very small. In the intermediate frequency area for a period of 45 ° to the slope, it is related to charge transfer resistance. In the low frequency region approximate a vertical straight line, it shows a good capacitance characteristic.

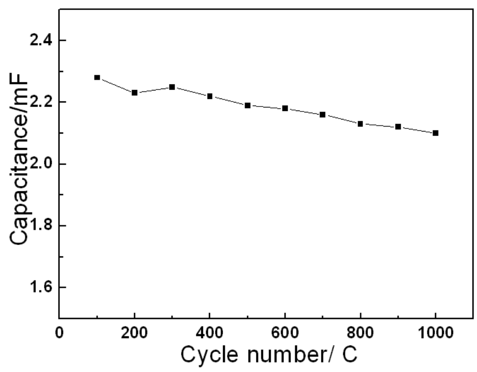

Figure 4. Cycle performance of the hybrid supercapacitor

Fig. 4 shows the cycle performance of the hybrid supercapacitor. At the beginning, the capacitance of the hybrid supercapacitor is 2.3 mF. At the end of 1000 cycles, the capacitance of the hybrid supercapacitor is 2.1 mF which indicates that 91.3 % of their initial capacitance can be retained. The results suggest that the hybrid supercapacitor has relatively high capacitance and excellent capacitive retention. Compared with other sampling, this significantly improves performance especially in the voltage. The results suggest that the hybrid supercapacitor has relatively higher capacitance and more excellent capacitive retention than other articles [16-19].

4. CONCLUSIONS

In summary, through the optimized combination of aluminum electrolytic capacitors anode and electrochemical capacitors cathode, using Ta/Ta_2O_5 as the anode, activated carbon as the cathode, we developed a work unit for 100 V voltage of the hybrid supercapacitor. Compared with the usual electrochemical capacitor working voltage, the capacitance had improved. The electrical performance test shows that it has high energy storage density and rapid charging and discharging ability, electrochemical spectrum impedance (EIS) analysis shows that it has good impedance characteristics and the frequency characteristics.

ACKNOWLEDGEMENTS
The work was supported by the Shandong province Natural Science Foundation of China (No.Y2008F23), Shandong province Science and Technology Development Plan (No. 2011GGB01123) and 863 programme (No.2012AA110407). We thank the anonymous reviewers for their helpful suggestions on the quality improvement of our present paper.

References

1. A. G. Pandolfo, A. F. Hollenkamp. *J. Power Sources*, 157 (2006) 11
2. W. C. Li, G. Z. Nong, A. H. Lu and H. Q. Hu. *J. Porous Mat.*, 18 (2011) 23
3. M. Jayalakshmi, K. Balasubramanian. *Int. J. Electrochem. Sci.*, 3 (2008) 1196

4. P. Simon, Y. Gogotsi. *Nat. Mater.*, 7 (2008) 845
5. D. Pan, S. Ma, X. Bo and L. Guo. *Microchim. Acta*, 173 (2011) 215
6. N. A. Yusof, N. Daud, S. Z. M. Saat, T. W. Tee and A. H. Abdullah. *Int. J. Electrochem. Sci*, 7 (2012) 10358
7. K. Wang, L. Zhang. *Int. J. Electrochem. Sci.*, 8 (2013) 2892
8. K. Wang, Ch. Qi, L. Zhang. *ICIC Express Letters*, 6 (2012) 2763
9. T. W. Kim, R. Ryoo, K. P. Gierszal, M. Jaroniec, L. A. Solovyov, Y. Sakamoto and O. Terasaki. *Mater. Chem.*, 15 (2005) 1560
10. Jörg Schuster, Guang He, Benjamin Mandlmeier, Taeeun Yim, Kyu Tae Lee, Thomas Bein and Linda F. Nazar. *Angew. Chem. Int. Edit.*, 51 (2012) 3591
11. Y. Tao, M. Endo, M. Inagaki and K. Kaneko. *J. Mater. Chem.*, 21 (2010) 313
12. R. Service. *Science*, 313 (2006) 902
13. H. Lu, W. Dai, M. Zheng, N. Li and J. Cao. *J. Power Sources*, 209 (2012) 243
14. J. Chen, N. Xia, T. Zhou, S. Tan, F. Jiang and D. Yuan. *Int. J. Electrochem. Sci.*, 4 (2009) 15
15. X. Lang, A. Hirata, T. Fujita and M. Chen. *Nature Nanotech.*, 6 (2011) 232
16. Yunpu Zhai, Yuqian Dou, Dongyuan Zhao, Pasquale F. Fulvio, Richard T. Mayes and Sheng Dai. *Adv. Mater.*, 23 (2011) 4828
17. K. De Wael, A. Verstraete, S. Van Vlierberghe, W. Dejonghe, P. Dubruel and A. Adriaens. *Int. J. Electrochem. Sci.*, 6 (2011) 1810
18. Q. X. Xia, K. S. Hui and K. N. Hui. *Mater. Lett.*, 69 (2012) 69
19. H. Pang, B. Zhang and J. Du. *RSC Adv.*, 2 (2012) 2257

© 2013 by ESG (www.electrochemsci.org)