PS-6-02

Extended Abstracts of the 2018 International Conference on Solid State Devices and Materials, Tokyo, 2018, pp1025-1026

Atmospheric-pressure-plasma-jet (APPJ) treatment on carbon cloth for reduce graphene oxide (rGO)-polyaniline (PANI)-chitosan supercapacitor

Yi-Chen Cheng[1*], Hung-Hua Chien[1], I-Chun Cheng [2], Cheng-Che Hsu[3], and Jian-Zhang Chen[1,4,*]

[1] Graduate Institute of Applied Mechanics, National Taiwan University, Taipei City 10617, Taiwan
[2] Department of Electrical Engineering & Graduate Institute of Photonics and Optoelectronics, National Taiwan University ,Taipei City 10617, Taiwan
[3] Department of Chemical Engineering, National Taiwan University, Taipei City 10617, Taiwan
[4] Advanced Research Center of Green Materials Science and Technology, Taipei City 10617, Taiwan

[*]Corresponding authors
Yi-Chen Cheng (02-33669423; r06543006@ntu.edu.tw)；Jian-Zhang Chen (02-33665694; jchen@ntu.edu.tw)

Abstract

We use APPJ to process carbon cloth before screen-printing rGO-PANI-chitosan nanocomposites that are used for the electrodes of supercapacitors. APPJ treatment increases the wettability, facilitating the contact between the electrolyte and electrode material, thereby improving the supercapacitive performance. APPJ treatment can improve the specific capacitance by 88%.

1. Introduction

Supercapacitors (SCs) are electrochemical devices possessing high power density and cycling stability. SCs typically have at least one of the two types of charge storage mechanisms: electrical double layer capacitance (EDLC) and pseudocapacitance. EDLC typical exists in carbon-based materials whereas pseudocapacitance occurs in metal oxides and conducting polymers. A composite consisting of both rGOs and PANI can take advantage of both charge storage mechanisms, rendering high capacitance value.

This study investigates a solid-state polyvinyl alcohol (PVA)-sulfuric acid (H_2SO_4) electrolyte supercapacitor with rGO-PANI-chitosan nanocomposites. With DC-pulse nitrogen APPJ treatment on carbon cloth prior to the coating process of the nanocomposites can significantly improve the capacitance value. It is attributed to the improved wettability by the APPJ treatment, which thereby improves the contact between the electrode and electrolyte, leading to improved capacitance.

2. General Instructions

2.1 Experimental

PANI and rGO powders were mixed with chitosan solution to make the pastes. The rGO-PANI-chitosan pastes were screen-printed on carbon cloth with and without APPJ treatment. The gel electrolyte was coated on an rGO-PANI-chitosan electrode. Afterwards, two gel-electrolyte coated rGO-PANI-chitosan electrodes were pressed mechanically on the gel-electrolyte sides to form a sandwich-type solid-state supercapacitor.

2.2 Morphology of rGO/PANI

Fig. 1 (a) and (b) show SEM images of screen-printed rGO-PANI-chitosan on carbon cloth with APPJ treatment. Particulate PANIs and flake-like rGOs can be observed.

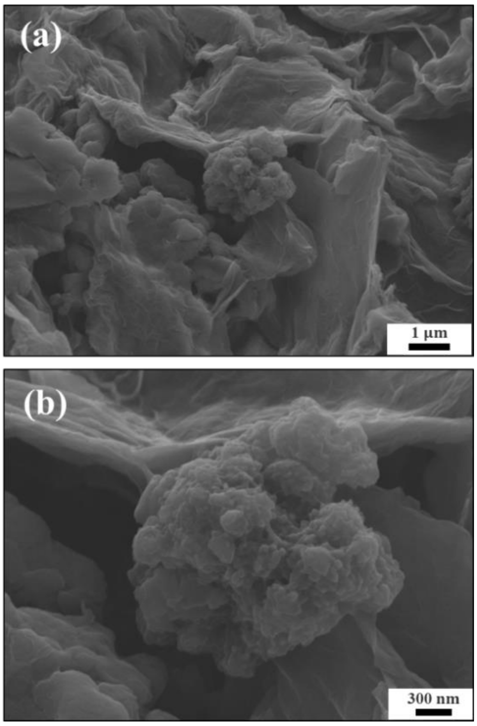

Fig. 1 (a) SEM image (10000x) and (b) magnified SEM image (30000x) of rGO /PANI.

2.3 Water contact angle of carbon cloth

Figs. 2 (a) and (b) show the water contact angle measurement results for non-treated and APPJ-treated carbon cloth. The non-treated carbon cloth had a high contact angle of 118.95°. After APPJ treatment, the wettability significantly improved, and the testing water droplet completely infiltrated into the carbon cloth.

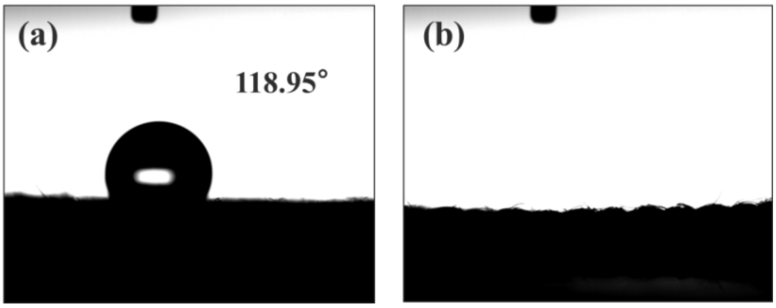

Fig. 2 Water contact angle of carbon cloth (a) without and (b) with APPJ treatment.

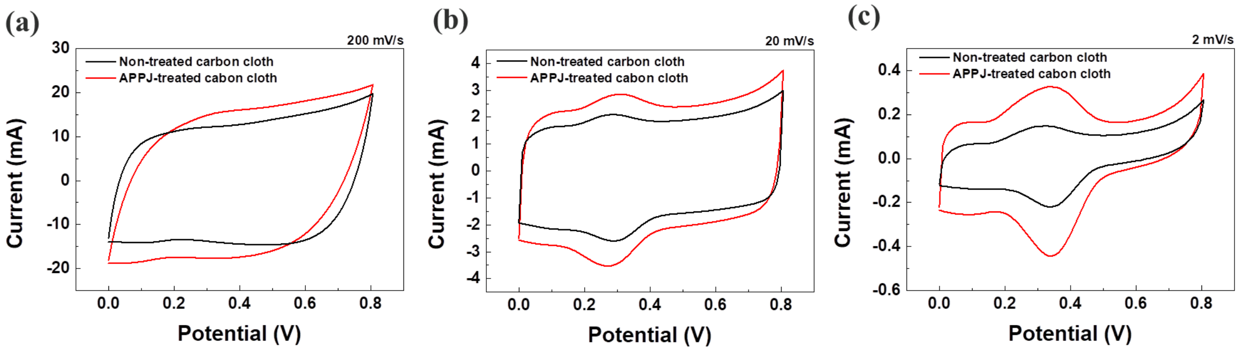

Fig. 3 Cycle voltammetry results under scan rates of (a) 200 , (b) 20 and (c) 2 mV/s.

2.4 Cycle voltammetry measurement of the supercapacitor

The areal capacitance C_A and specific capacitance Cs can be calculated based on equations (1) and (2). [1]

$$C_A = \frac{2}{Av\Delta V}\int_{V_a}^{V_c} I(V)\,dV \qquad (1)$$

$$C_S = \frac{2}{mv\Delta V}\int_{V_a}^{V_c} I(V)dV \qquad (2)$$

In equations (1) and (2), I is the response current, v is the potential scanning rate, Vc-Va is the potential window, m is the active mass of one electrode, and A is the apparent area of one electrode. Table I lists the areal and specific capacitance values of the rGO-PANI-chitosan supercapacitors on non-treated and APPJ-treated carbon cloth. The two-electrode CV measurement shows that the specific capacitance value increased from 210.36 F g^{-1} (non-treated carbon cloth) to 395.82 F g^{-1} (APPJ-treated carbon cloth), as evaluated under a potential scan rate of 2 mV s^{-1}.

Table I Areal and specific capacitance at different scan rates

Potential scan rate (mV/s)	Non-treated carbon cloth		APPJ-treated carbon cloth	
	C_A (mF/cm^2)	Cs (F/g)	C_A (mF/cm^2)	Cs (F/g)
2	65.90	210.36	131.94	395.82
20	124.01	395.74	160.34	481.51
200	79.74	254.50	87.50	262.48

3. Conclusions

Scan-mode APPJ treatment reduces the water contact angle of the carbon cloth from 118.95° to 0°. The two-electrode CV measurement shows that the specific capacitance value of rGO-PANI–chitosan supercapacitor are increased from 210.36 F g^{-1} (non-treated carbon cloth) to 395.82 F g^{-1} (APPJ-treated carbon cloth), as evaluated under a potential scan rate of 2 mV s^{-1}.

Acknowledgements

JZC gratefully acknowledges funding support from the Ministry of Science and Technology of Taiwan under grand nos. MOST 105-2221-E-002-047-MY3 and MOST 106-2221-E-002-193-MY2. This research is supported by the Ministry of Education (107L9006) and the Ministry of Science and Technology (MOST 107-3017-F-002-001). The cleanroom facility was provided by the Nano-Electro-Mechanical-Systems (NEMS) Research Center at National Taiwan University. The authors would like to thank Ms. Yuan-Tzu Lee of the Instrumentation Center at National Taiwan University for helping with the SEM operation.

References

[1] Y. Xu, Z. Lin, X. Huang, Y. Liu, Y. Huang, and X. Duan, "Flexible solid-state supercapacitors based on three-dimensional graphene hydrogel films," ACS nano, vol. 7, no. 5, pp. 4042-4049, 2013.

[2] H.-H. Chien et al., "Improved performance of polyaniline/reduced-graphene-oxide supercapacitor using atmospheric-pressure-plasma-jet surface treatment of carbon cloth," Electrochimica Acta, vol. 260, pp. 391-399, 2018.