

Nano-Ag Embedded into Graphite Prepared by Mechanofusion and Hard Carbon Coating for High-Performance Anode Materials of Li-ion Batteries

Jin-Ming Chen, Mao-Huang Liu, Yu-Run Lin,
 Ji-Ru Zheng, Qing-Hui Peng
 Materials Research Laboratories
 Industrial Technology Research Institute
 Taiwan 31040, R.O.C.
 E-mail: linyinurun@itri.org.tw

2. K. Nishimura, H. Honbo, S. Takeuchi, T. Horiba, M. Oda, M. Koseki, Y. Muranaka, Y. Kozono, H. Miyadera, *J. Power Source* **68**, 436 (1997).
 3. R. Pfeffer, R.N. Dave, D. Wei, M. Ramlakhan, *Power Technol.* **117**, 40 (2001).

1. Introduction

Ag is recognized as an effective additive to improve the anode performance of carbon for Li-ion secondary batteries, and it has benefits of high theoretical capacity and low working potential [1]. The capacity performance of the Ag/graphite composite can be improved by chemical deposition method [2]. The results are not good enough, and it may be due to the residual impurity of the chemical deposition.

Mechanofusion as a composite process provides a convenience for dispersion of Ag on graphite (Ag/G), and when the constituents differ in size there is an increase tendency for segregation [3]. The volume expansion stress of the lithium alloyable metal (AgLi or Ag₃Li₁₀) could be solved by reducing the size of Ag particles, by the way. The amorphous carbon coverage on Ag/G (C/Ag/G) offers further wrap of Ag/graphite composite to prevent Ag falling off from the graphite during charge and discharge.

2. Experimental

In mechanofusion process, 10g of the commercial Ag particle with diameter of 100-200 nm and 90g of the graphite with 22 μm were applied to construct the composite, Ag/G. In amorphous carbon coating process, 90g of Ag/G was added into 200 ml of a 50 vol% alcohol aqueous solution with 10g of epoxy resin, then that became slurry. For concentrating, the slurry was heating at 80°C under atmosphere. It was then heated at 220°C for 1 h, 700°C for 2 h and 800°C for 4 h in a furnace. The heating process in the furnace was all under Ar flow to remove the side-products due to polymerization and carbonization. The final products were ground and sieved through 200 mesh before being employed to fabricate electrodes for the coin cell test.

Electrochemical measurement was performed within coin cells, using lithium as counter electrode and the Samsung electrolyte (EC/PC/EMC/DMC=3/1/4/2 by vol.).

3. Results and Discussion

Ag/G and C/Ag/G were shown in Fig. 1. The first galvanostatic discharge performances of Ag/G, C/Ag/G and the origin electrodes were shown in Fig. 2. Both the curves of Ag/G and C/Ag/G, they exhibit obvious plateaus at ca. 0.3V and have a tile after the plateaus. In the discharge curve of C/Ag/G, the tile was more serious than Ag/C. The plateaus ca. 0.3V could be ascribed to the formation of the Li-Ag alloys, and the serious tile could be assigned to the Li-extraction process of amorphous carbon. The first charge and discharge capacities were collected in Table 1. On the basis result, more than 20% of capacity enhancement, in comparison with bare graphite, can be achieved by using mechanofusion and amorphous carbon coating.

References

1. J. Suzuki, O. Omae, K. Sekine, T. Takamura, *Solid State Ionics* **152-153**, 111 (2002).

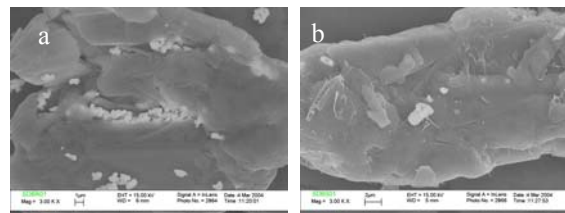


Fig. 1. (a) SEM micrograph of Ag/G (b) C/Ag/G.

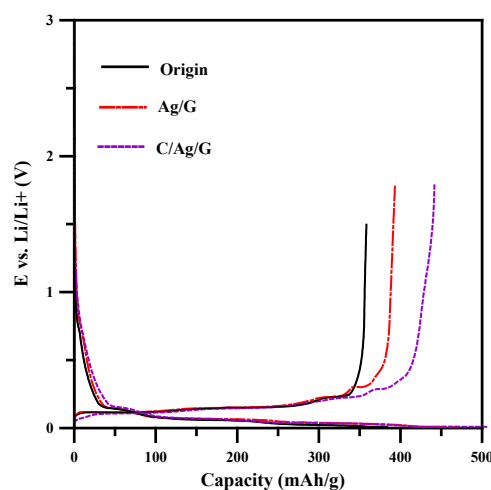


Fig. 2. The first galvanostatic performances of the origin, Ag/G, and C/Ag/G electrodes.

Table 1 Comparison of capacities in the first cycle Li insertion and extraction reactions between 0 and 2V at 5 mA g⁻¹.

Electrode (composition)	1 st Li-insertion (mAhg ⁻¹)	1 st Li-extraction (mAhg ⁻¹)	1 st cycle efficiency (%)	Irreversible capacity (mAhg ⁻¹)
Origin (100)	401	360	89.8	41
Ag/G (20/80)	470	393	83.6	77
C/Ag/G (1.4/19.7/78.9)	511	443	86.7	68