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GeO_2/C Composite Fabricated by Sol-gel Method as an Anode Material for Lithium Ion Batteries

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Germanium and its compounds have showed the most promising properties as an anode material for Li-ion batteries due to their high specific capacity, high electrical and ionic conductivities. Theoretical specific capacity of Ge is 1624 $mAh \cdot g^{-1}$ corresponding to $Li_{22}Ge_5$, which is four times higher than that of commercial graphite (372 $mA \cdot g^{-1}$ corresponding to LiC_6). Nevertheless, the specific capacity of Ge (1624 $mAh \cdot g^{-1}$) is smaller compared to that of Si (4200 $mAh \cdot g^{-1}$). The higher capacity of Si than that of Ge is due to their density differences which are 2.329 $g \cdot cm^{-3}$ and 5.323 $g \cdot cm^{-3}$, respectively. However, Si and Ge show almost similar volumetric capacities i.e. 9782 $Ah \cdot l^{-1}$ for Si and 8644 $Ah \cdot l^{-1}$ for Ge.

Unfortunately, the capacity of germanium/germanium compound based electrodes declines after a few cycles due to their volume expansion during charge/discharge. It is important to suppress capacity fading of germanium /germanium compound based anodes for Li ion batteries. Many researches have focused on resolving this crucial problem by making germanium/germanium compound based anodes either in thin film form or its composites with carbon. Currently, the Ge/GeO_2 compound based anode materials are prepared by many methods such as sputtering [1], CVD [2], and wet chemical routes [3]. However, each of these techniques involves the use of expensive chemical or equipment. In this research, GeO_2 was synthesized by simple sol-gel method, and after that the GeO_2 was encapsulated with carbon to make GeO_2/Carbon composite.

Germanium ethoxide, polyvinyl-pyrrolidone and ethanol were used as the precursors to synthesize the GeO_2/carbon.

Fig. 1 shows the XRD pattern of GeO_2 and GeO_2/carbon. The XRD pattern was compared and matched with GeO_2 (PDF#43-1016; hexagonal); confirmed the formation of single phase GeO_2 in the product.

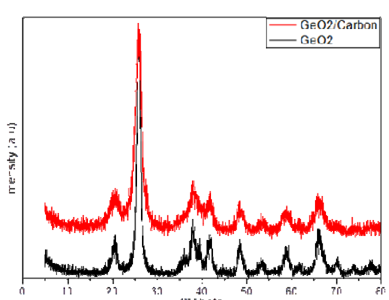

Fig. 1. XRD pattern of GeO_2 and GeO_2/carbon.

Fig. 2 shows the SEM micrograph of as-synthesized GeO_2 and GeO_2/carbon. It can be clearly seen that the nano particles with size ranging from 10 to 15 nm for GeO_2 and 15 to 20 nm for GeO_2/carbon.

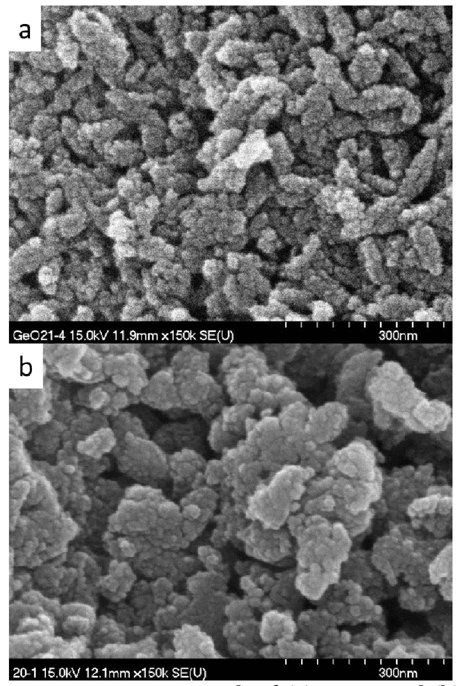

Fig. 2. SEM micrograph of (a) GeO_2 and (b) GeO_2/carbon.

Obtained GeO_2 and GeO_2/carbon were characterized for their electrochemical charge-discharge behaviors. Fig. 3 shows the specific reversible capacities of GeO_2 and GeO_2/carbon. The specific capacities of GeO_2 and GeO_2/carbon at 0.1C-rate were about 1410 and 910 $mAh \cdot g^{-1}$ respectively at the first cycle.

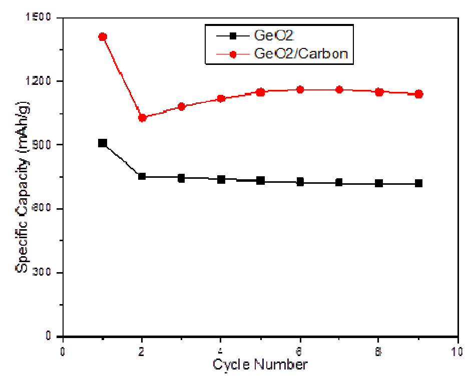

Figure 3: Specific reversible capacities of GeO_2 and GeO_2/carbon

The cyclic lives of synthesized anodes are under-investigation and it can be observed from its initial data that the anode shows steady performance till the obtained data. However, further cycling data is necessary for making any stamen about the stability in its performance. The initial results demonstrate that the synthesized GeO_2/carbon can be used as an active Li storage material for lithium ion batteries.

References

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