Preparation and Characterization of Silicon-Germanium-Tin Nanocomposites on Nitrogen Doped Reduced Graphene Oxide for Use as Anode materials in Lithium-ion batteries

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Lithium-ion batteries are widely used as energy sstorages in electronic devices . The current commercial lithium ion battery is based on the use of graphitic carbon anode which provides low theoretical capacity . Therefore, new materials that have higher theoretical capacities and energy density are attracted especially silicon, germanium, and tin . Nonetheless, using of these elements as bulk electrode materials having high volumetric change leads to electrode cracking during cycling. Nitrogen-doped reduced graphene oxide (NrGO) is proper to use as supporting materials to solve this problem . Because of its high surface area can act as excellent supportor material to obstruct the volumetric change . In addition, nitrogen-doping level could improve the conductivity, rate capability and reversible capacity of graphene sheet . Silicon-germanium-tin nanocomposites on NrGO are synthesized in this research by solution method . Two-step processes are applied. Firstly, germanium solution was reduced by cold $NaBH_4$ solution to get germanium nanoparticles . Secondly, silicon-germanium-tin nanocomposites were prepared by solution method on NrGO.

The composites were primarily characterized by x-ray diffraction, scanning electron microscopy and transmission electron microscopy equipped with energy dispersive spectroscopy. The small-sized particles of silicon-germanium-tin composite is well distributed on NrGO. Finally, these anode materials were tested in lithium-ion batteries by haft-coin cell assembly. The electrochemical properties were measured. The highest initial capacity of 776 mAh/ g was observed in 20Ge/NrGO sample at current density of 100 mAh/ g . The cycle performance and galvanostatic charge/ discharge profiles illustrated that electrodes provided good stability although using more than 50 cycles. As consequence, these nanocomposites have the possibility to exhibit high capacity. NrGO can be a stabilizer to buffer volume change of active materials for used as anode materials. These composites might be used as anode materials for the high-performance lithium ion batteries in the future.

References:

[1] Y.Fan, Q.Zhang, Q.Xiao, X.Wang, K.Huang, Carbon 59 (2013) 264.
[2] D.Wang, M.Gao, H.Pan, J.Wang, Y.Liu, J .Power Sources 256 (2014) 190.
[3] K .E .Aifantis; S .A .Hackney; R .V .Kumar, High Energy Density Lithium Batteries :WILEY-VCH Verlag GmbH & Co .KGaA, Weinheim, (2010) 70-72.
[4] Z.S. Wu, W. Ren, L. Xu, F. Li, and H. M. Cheng. ACS Nano, 5 (2011) 5463–5471.