Si/C nanocomposites internally-wired with graphene for high capacity Li-ion battery anode

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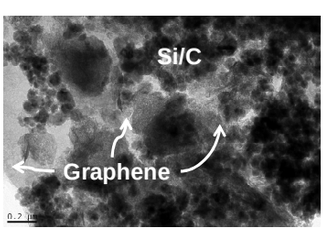
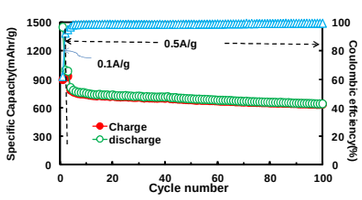
The energy density of LIBs can be improved when advanced anode materials are available to replace the graphitic carbon anode whose theoretical capacity is limited to 372 mAh g^{-1}. Promising candidates are lithium metal alloys or transition metal oxides. Among them, silicon is an ideal anode material, because it offers low voltage for charging and the highest specific and volumetric capacities ($Li_{15}Si_4$ ≈ 3,579 mAh g^{-1} and 8,340 mAh ml^{-1}) among known elements. In spite of these highly appealing features, it has long been a critical challenge to design silicon-based electrode materials in a scalable way so as to maintain its high-capacity for prolonged cycles against both the disastrous electrode pulverization due to huge volume variations (~300%) and the instability of solid-electrolyte-interface (SEI) layers, accompanying during charge/discharge cycles.

To overcome these inherent problems, electrodes comprising Si nanoparticles, carbon and small amount of graphene sheets (GS) have been prepared using a facile and scalable sol-gel process followed by a thermal carbonization. With a small amount of graphene sheets, i.e., 1~10 wt%, in the composite, the Si/C/GS composites exhibited remarkably enhanced cycling stability compared to the standard Si/C composite without GS.

X-ray diffraction (XRD), scanning electron microscopy (SEM) and high-resolution transmission electron microscopy (HR-TEM) analyses and conductivity measurements indicated that Si nanoparticles were evenly coated with carbon and the Si/C particles were in intimate contact with flexible and conducting GS in the Si/C/GS composite. From the galvanostatic cycling tests, the Si/C/GS composites showed reversible capacity of around 700 mAh/g at the current density of 500 mA/g with stable cycling up to 100 cycles.





1. S. D. Beattie, D. Larcher, M. Morcrette, B. Simon, J. M. Tarascon, “Si electrodes for li-ion batteries - A new way to look at an old problem”, *J. Electrochem. Soc.* **2008**, *155*, A158.
2. J. K. Lee**,** Mayfair C. Kung, Lynn Trahey, Michael Missaghi, and Harold H. Kung “Nanocomposites Derived from Phenol-Functionalized Si Nanoparticles for High Performance Lithium Ion Battery Anodes” *Chem Mater*. **2009**, *21*, 6-8.
3. J. K. Lee**,** Kurt B. Smith, Cary M. Hayner, and Harold H. Kung, “Silicon Nanoparticles-Graphene Paper Composite for Li Ion Battery Anodes” *Chem. Commun*. **2010**, 46(12), 2025-2027.