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Materials Science and Engineering Seminar Series

Materials Research at Carnegie Mellon

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"Silicon-Carbon based Nanocomposite Anodes for Li-ion Batteries"

Friday, January 16, 2009
11:30 A.M. Seminar in Baker Hall 136A

Different silicon-carbon based nanocomposite materials have been synthesized and characterized for lithium-ion battery anode applications. The main goal of this research is to develop novel lithium-ion battery anodes to match the energy needs of modern computing and electronic devices, which demand safe, compact, light-weighted, high energy density and long lasting power source. In this study, Si/C/Al composite powder has been synthesized by thermal treatment of high-energy mechanical milled composite precursors comprising graphite, silicon, aluminum and polymethacrylonitrile (PMAN). The polymer has been used to suppress the interfacial diffusion reactions between graphite, silicon and aluminum, which otherwise lead to the formation of electrochemically inactive SiC and Al_4C_3 intermetallics during high energy mechanical milling (HEMM). The resultant Si/C/Al composite of nominal composition C-20wt.% Si-5wt.% Al exhibits a reversible capacity of ~650mAh/g up to 30 cycles at a charge/discharge rate of 340mA/g. Single-walled carbon nanotubes (SWNTs) also introduced in to the silicon-carbon system by dispersing SWNTs via high power ultrasonication into a pre-milled Si/C composite mixture, followed by subsequent thermal treatment. A nanocomposite with nominal composition of Si-35 wt.% SWNTs-37 wt.% exhibits a reversible discharge capacity of ~900mAg^{-1} with an excellent capacity retention of capacity loss of 0.3% per cycle up to 30 cycles. Functionalization of the SWNTs with LiOH significantly improves the cyclability of the nanocomposite containing Si-45 wt.% SWNTs-28 wt.% exhibiting a reversible capacity of 1066 mAhg-1 displaying almost no fade in capacity up to 30 cycles. The improved electrochemical performance is hypothesized to be attributed to the formation of a nanoscale conductive network by the dispersed SWNTs which successfully results in maintaining electrical contact between the electrochemically active particles during cycling.

Wei received his Bachelor's degree in Ceramic Engineering from East China University of Science and Technology in 1997, and Master's degree in Materials Science and Engineering from Carnegie Mellon University and 2006. He is currently a Ph.D. candidate under the guidance of Prof. Kumta.