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High-performance lithium-Ion batteries using germanium nanomaterials as the anode material

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In this talk, it will be demonstrated that both dedecanethiol-passivated Ge nanowires and graphene-germanium composites can serve as excellent LIB anodes. Germanium (Ge) is considered as a high-capacity anode materials for lithium-ion batteries (LIBs) due to its high theoretical capacity of 1384 mAh/g, which is four times larger than graphite anode (372 mAh/g). However, the dramatic volume changes (~300%) of Ge during the insertion/extraction usually cause crack and pulverization of electrode, and loss of electrode contact, making the capacity fade rapidly after several cycles. Ge nanostructures can effectively accommodate the volume changes, tolerate relaxed mechanical strain, and provide channels for efficient electron transport, but the anode performance still decayed rapidly within a few tens of cycles.

Dodencanethiol-passivated Ge nanowires exhibit an excellent electrochemical performance with a reversible specific capacity of 1130 mAh/g. The functionalized Ge nanowires show high-rate capability having charge and discharge capacities of ~555 mAh/g at rates as high as 11 C. An aluminum pouch type lithium cell using a LiFePO4 cathode was assembled to provide larger current (~30 mA) for uses on light-emitting-diodes (LEDs) and audio devices. This study shows that organic monolayer-coated Ge nanowires represent promising Ge-C anodes with very low carbon content (~2-3 wt %) for high capacity, high-rate lithium-ion batteries and are readily compatible with commercial slurry-coating process for cell fabrication.

Carbon-coated Ge nanoparticles/RGO (Ge/RGO/C) sandwich structures were formed via a carbonization process. The high nanoparticle-loading nanocomposites exhibited superior Li-ion battery anode performance when examined with a series of comprehensive tests, such as receiving a practical capacity of Ge (1332 mAh/g) close (96.2%) to its theoretical value (1384 mAh/g) when cycled at a 0.2 C rate and having a high-rate capability over hundreds of cycles. Furthermore, the performance of the full cells assembled using a Ge/RGO/C anode and an LiCoO2 cathode were evaluated. The cells were able to power a wide range of electronic devices, including a light-emitting-diode (LED) array consisting of over 150 bulbs, blue LED arrays, a scrolling LED marquee, and an electric fan.

Biography

Hsing-Yu Tuan has completed his PhD at the age of 27 years from The University of Texas at Austin and postdoctoral studies from the same school. He is the Associate Professor of Department of Chemical Engineering, National Tsing Hua University, Taiwan. He has published more than 40 papers in reputed journals. He was awarded with many honors, such as Ta-You Wu Memorial Award and Outstanding Young Research Scholar in Taiwan.

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