Core@shell silicon-carbon nanoparticles with a tunable shell thickness: performances as battery anodes

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Nanometric silicon appears as an interesting candidate to improve the capacity of lithium-ion batteries anodes because its theoretical specific capacity is over 10 times that of current commercial graphite electrodes. A major issue with nanosilicon anodes is the continuous formation of solid electrolyte interphase (SEI) due to the significant volume changes in the material during lithiation-delithiation. Coating the silicon surface with carbon has proved to protect it, as a more stable SEI is obtained.

For this purpose, we synthesize core@shell silicon-carbon nanoparticles by a using a double-stage laser pyrolysis reactor [1]. This gas-phase technique allows one-step synthesis of a silicon core coated by a carbon shell. The size and the size distribution, as well as the shell's thickness, can be controlled by the modification of parameters. This wall-less process leads to clean interfaces.

In this work the synthesis of carbon coated crystalline nanosilicon (30 nm) with various carbon contents, up to 20 % w/w, will be presented. These Si@C particles present a clear silicon-carbon interface as shown by STEM-EELS. The galvanostatic performance comparison indicates that the coulombic efficiency is improved by a greater carbon content and power rate experiments indicate that an optimum exists. Finally, by using electrochemical impedance spectroscopy (EIS), a comparison of SEI resistances for coated and non-coated particles will be presented.

[1] Sourice et al, ACS Appl. Mater. Interfaces 2015