Abstract

The need for increasing the capacity of electrical energy storage of portable devices, and electric vehicles, demands a new suitable battery technology. The main issue addressed in this work is the limited capacity of anode materials. Commercial Li-ion battery anodes are made of graphite which has a practical capacity of about 350 mA h/g. A large scale improvement of graphite based anodes is limited by its theoretical capacity of 372 mA h/g. It is clear that, in order to have higher specific capacities, other materials have to be used to make anodes.

In this work the suitability of silicon, prepared using a special gas phase process – Laser Assisted Chemical Vapour Pyrolysis (LaCVP), as a potential anode material for lithium ion batteries was systematically investigated. Using this method large quantities of 3 different nanosilicon powders were produced, which have a small particle size (20-70 nm), a uniform particle size distribution, and a very low content of oxide (a few %). Nevertheless, this oxide layer is thick enough to enable safe handling of powders in the air atmosphere. The performances of LaCVP synthesized powders were compared to commercial powders.

In comparison to a current benchmark commercial silicon important differences in particle size and particle composition were found which, as shown, critically affect the rheological properties of the corresponding electrode slurries. In order to overcome the rheological problems of prepared nanosilicon, a spraying method was introduced and optimised, instead of using the usual casting technique for slurry application. Interestingly, the optimised electrodes show similar electrochemical performance, regardless of the particle size or composition of nanosilicon. This unexpected result is explained by the unusually high resistance of electrochemical wiring in silicon based electrodes (about 60 Ω per 1 mg/cm^{-2} of material loading). Despite that, the optimised material still shows a capacity up to 1200 mA h/g at a relatively high loading of 1.6 mg/cm^2 and after 20 cycles. On the other hand, by decreasing the loading to below ca. 0.9 mg/cm^2 the wiring problems are effectively overcome and capacities close to theoretical values can be obtained.

Keywords: Silicon, Anode, Lithium batteries, Li-ion batteries, Laser assisted Chemical Vapour Pyrolysis, Rheology, Particle size