

Silicon/graphene composites for high-energy batteries

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Within the last decade, extensive efforts have been made in the field of electrochemical power sources, to meet the increasing demands of numerous industries and applications for more powerful, long-lasting, safer and greener energy storage. Above all, energy storage market is undoubtedly driven by the automotive industry and the prospective electrification of the power train, which lead to the development of novel, large cell designs with 20-50 times higher energy content than common mobile phone batteries. (1) Simultaneously, the beginning of the so-called carbon age, meaning particularly the discovery of carbon nanotubes and graphene in 1991 and 2004 (2) offered exciting new possibilities for the tailoring of micro- and nano-sized applications and triggered an almost exponential growth in scientific publications in this field (3). Since then, pioneering developments have been reported especially in the area of flexible, portable and wearable electronics (4).

For energy storage systems in general and especially for lithium ion batteries, the demand for high-energy and high-power applications can only be fulfilled by the development of new generations of electrochemically active materials. Here, the use of silicon as active material on the negative electrode is most promising, since silicon offers exceptional high volumetric and gravimetric lithium storage capabilities as well as low charging/discharging potentials. However, this high storage capability is accompanied with high volume changes during lithium insertion/extraction, which causes a rapid decay in dimensional stability of the host material (5). The use of graphene-related materials can help to overcome these crucial problems, as graphene offers a highly conductive and mechanically stable matrix that can suppress or buffer this large volume expansion (6) (7). Consequently, graphene-related materials improve the cycling stability by retaining the native structural integrity as well as the electrode porosity.

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