Silicon nanoparticles wrapped between few-layer graphene flakes as anodic material for Li-ion batteries

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Silicon is one of the most promising candidate for the next generation Li-ion batteries. In fact, through an alloying reaction to $Li_{4.4}Si$, silicon is theoretically able to deliver a specific capacity of ≈4200 $mAhg^{-1}$. Unfortunately, such process is associated to a large volume expansion (>300%) that can induce cracks and pulverization of the electrode during cycling, eventually leading to rapid capacity fading in a few cycles [1]. Reduction of silicon particles at nanometric level or their encapsulation in a carbonaceous matrix are some of the commonly adopted strategies to control the volumetric changes, thus improving the performance of the electrode in terms of both life and rate capability [2]. In this context, graphene represents a promising substrate to host the active nanoparticles [3] thanks to its high conductivity, mechanical flexibility and chemical stability [4-6].
Here, we report a facile mechanochemical approach, easily scalable to industrial production, to prepare a silicon-graphene composite able to achieve good electrochemical performance in both half and full cell configurations.
Few-layers graphene (FLG) are produced by liquid phase exfoliation (LPE).[7,8] We exploit the wet jet mill (WJM) process, in which the exfoliation of graphite is promoted through the shear forces produced by the solvent triggered at high speed [9]. The WJM allows a production rate of FLG of ~20g per hour. The obtained FLG flakes have lateral size of ~600nm and ~3nm in thickness.[9] Then, a commercial silicon nanopowder (dimension <100nm) is incorporated into the graphene layer to obtain the hybrid material. Electrochemical performance in lithium cell proved that the obtained silicon-graphene hybrid is able to achieve ≈2000 mAh/g with a Coulombic efficiency of 98% after 20 cycles.

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