In-Situ Growth of Conducting Metal Organic Framework on Silicon Nanoparticles for High Performance Lithium Ion Batteries

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Lithium-ion batteries (LIBs) are currently the preferred choice as power source for portable electronic devices. Nevertheless, LIBs have not fully satisfied the market's needs for higher energy density for portable devices and electric vehicles due to the intrinsic limitation of conventional electrode materials such as a graphite. Therefore, scientists have searched for alternative electrode materials with higher capacity. Silicon, which can be alloyed with Li, has a potential to replace the carbon based anode materials, due to its high theoretical specific capacity and natural abundance. However, the cyclability and rate capacity of Si based electrodes are still limited. In particular, the low Li diffusivity, intrinsic electrical conductivity, and the poor structural stability caused by its large volume change (>300%) during Li-alloying should be addressed for the practical application of Si based electrodes. Thus far, the strategies to make Si nanostructures and employ carbon coating have been used. Nevertheless, to improve the rate capability of Si to the level comparable to that of graphite, a breakthrough is needed.

In the present work, a highly porous Si nanoparticles coated with 2D-porous metal organic framework are proposed to be used as a potential anode material for LIBs. The composites of Si nanoparticles and MOF matrix exhibited many advantages. The intrinsic open channels of the MOF network are advantageous for the movement of Li-ions to the inside of electrode through liquid electrolyte, leading to improving the rate capability of the Si based electrode. Further, the highly porous Si nanoparticles provided high capacity and the flexible porous MOFs matrix helped to mitigate the volume change of the electrode. The porous carbon framework with uniformly distributed metal ions was also beneficial for improving conductivity and Li storage. These all characteristics of the electrode consisting of in situ growth of conductive metal organic framework on the porous Si nanoparticles makes it as an ideal alternative anode candidate for high performance LIBs.