Preparation of Carbon/Silicon Hybrid Nanostructured Anodes for Lithium ion Batteries by CVD and Liquid Phase Deposition

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C/Si hybrid systems for Li-ion batteries have been studied for many years.[1] C properties (softness, onductivity, intercalation of Li+) are ideal to prevent the volumetric expansion of Si lattice due to alloying with lithium. The contemporary use of C and Si allows to combine the high capacitance of SiLix alloys (up to 4200mAh/g for x=4.4) with the traditional graphitic anodes safety standards.[2] However, these hybrid materials cannot always offer the expected durability and integrity, and capacitance fades over time.[3] Actually, Si must be well dispersed inside the C matrix, with the highest possible Si/C ratio to maximize the capacitance, while C materials must be porous, with large surface area and optimized pore dimension to shorten Li+ pathways.[2]
Here we show a method to design customized composite C/Si nanostructured materials, where the interconnected C matrix is obtained by successive chemical vapor deposition (CVD) steps, with exceptional control over morphology and structure, while Si is added by liquid phase deposition over and inside the matrix after each CVD step. In this way the active component is embedded inside a light porous support which can accommodate Si dimensional variations without losing electrical contact. A suitable example is a hybrid structure made by growing C nanowalls with a peculiar H2 free CVD process[4], and through the deposition of Si nanoparticles by dip coating of a stable suspension. This material was built over conductive carbon paper, and the obtained monolithic anode was tested in T cell at 0.04-1.2V vs Li/Li+ with Li as counter electrode. The material offers a far superior retention, maintaining stability over several cycles, compared to an uncovered Si electrode. The developed route paves the way to the fabrication of customized nanomaterials for energy production and storage devices.

[1] Adv Mater 2014, 26, 758
[2] Angew Chem Int Ed, 2020, 59, 110
[3] Nat Energy 2016, 1,15029
[4] AIP Conf Proceed 2017, 1873, 020006