Mesoporous Silicon/Carbon Composites derived from Zeolites for High-Performance Lithium-ion Battery Anodes

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Silicon which has high theoretical capacity (3579 mA h g^{-1} as $Li_{15}Si_4$) and low working voltage (~0.4 vs. Li/Li^+)[1,2] is an ideal anode material for many formats of high-energy lithium-based batteries. For the practical use of silicon anodes, however, key issues arising from the large volume change of silicon during cycling must be addressed by the facile structural design of silicon.

In this study, we prepared mesoporous silicon (mpSi-Y) microparticles in high yield by magnesiothermic reduction (MR) of commercial zeolite Y (SiO_2/Al_2O_3=80) as a silica precursor in the presence of mineral heat scavengers[3]. The mpSi-Y forms microparticle aggregates having primary silicon particles of 30 nm in diameter, large pore volume (0.49 cm^3/g) and wide open pore size (24 nm). With these appealing structural features of mpSi-Y, mpSi-Y/C composites showed excellent electrochemical responses such as high specific capacities, high rate capabilities and superior Coulombic efficiencies as well as long cycle life, whereas conventional SiNP (silicon nanoparticle)/C demonstrates limited cycle life. These enhanced electrochemical responses of mpSi-Y/C composites are further manifested by low impedance build-up, high Li ion diffusion rate, and small electrode thickness changes after cycling compared with those of SiNP/C composite.

In addition to the outstanding electrochemical properties, the low-cost materials and high-yield processing make the mpSi-Y/C composites attractive candidates for high-performance and high-energy Li-based battery anodes.

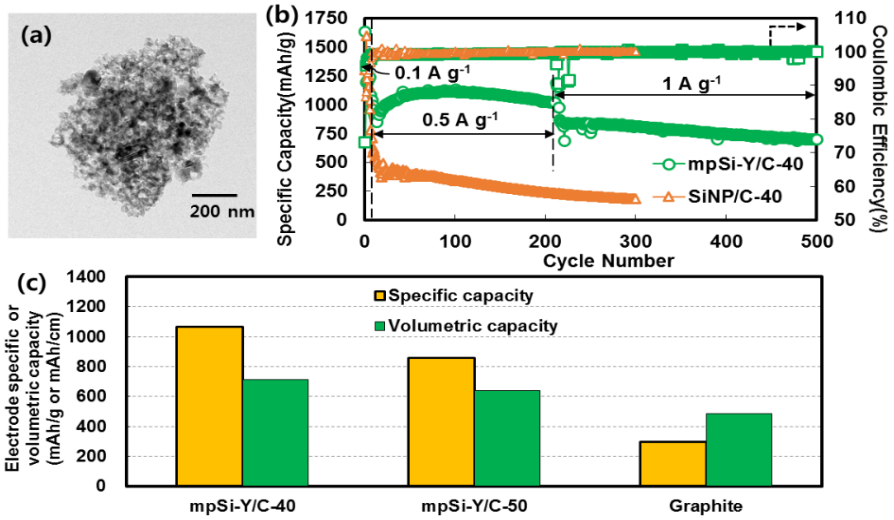

Figure 1. (a) TEM image mpSi-Y, (b) cycling performances of mpSi-Y/C-40 and SiNP/C-40 and (c) comparison of the specific and volumetric capacities of various electrodes.

References:

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