Fast and Efficient Synthesis of Sand to Nano-Silicon: Towards Energetic and Friendly Lithium-Ion Battery Application

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Silicon is highly promising anode material for energetic and beneficial Li-ion battery application due to its highest specific capacity (4200 mAh g^{-1}) among the anode materials, and non-toxicity. In spite of several advantages of Si, it is limited to use in Li-ion battery application due to huge volume expansion problem (>300%). In the present approach, a highly abundant, environmental compatible and low-cost precursor, sand (SiO_2) is reduced to nano elemental Si form via magnesiothermic reduction using microwave heating. In this approach, a crucial role of Mg particles size has been found. The Mg particle size is optimized for the complete conversion of sand to silicon. It was found that the critical Mg particle size 105 – 150 µm for complete conversion of sand to silicon at 800 °C, takes only 5 minutes microwave heating. The advantage of complete conversion of sand to silicon due to critical Mg particle size forbids the hydrogen fluoride purifying step which is extremely corrosive and toxic to dissolve the unreacted SiO_2 particles in the Si powder. Battery grade Si nanoparticles (SiNPs) is prepared by the scalable and green carbon coating technique. The carbon coating on the SiNPs is obtained uniquely via soaking the SiNPs into the green chemical that is furfuryl alcohol (FA) followed by polymerization and carbonization of FA on to the SiNPs. A full cell is fabricated using lithium cobalt oxide as cathode and carbon coated silicon as an anode that performs excellently with high volumetric capacity (1649 mAh cm^{-3}) at 0.5 C rate (C = 4200 mAh g^{-1}).

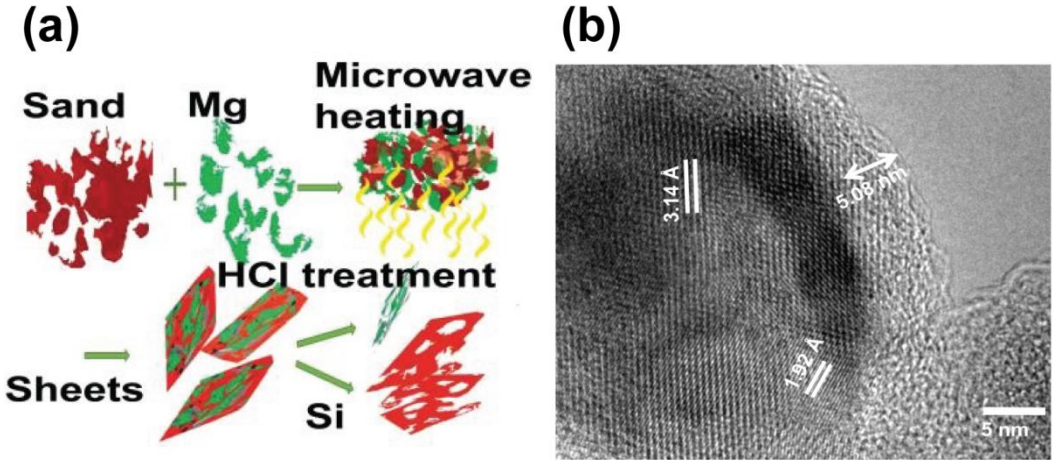

Figure: (a) Preparation of silicon from sand using magnesiothermic reduction using microwave heating and (b) Carbon coated SiNPs

Reference:

[1] J. Ryu, D. Hong, S. Choi, S. Park, ACS Nano. 10 (2016) 2843–2851.