Increased Charge Rate and Capacity for Olivine Li-Ion Batteries via Efficient, Upcycled Nanoscale Electrodes

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Lithium-ion batteries are used as the power source for a myriad of devices, from smartphones to electric vehicles. The main issues preventing further growth and development of these batteries are safety and capacity - both of these must be addressed in order to secure the future of the Li-ion energy market. A possible solution to these limitations may lie in adaptation of silicon anodes; Si's specific capacity can reach 4.2 Ah g-1, 12x that of the most commonly used anode, graphite. To date, however, Si anode technology remains untapped due to its massive volume change and instability during Li cycling. Concurrently, Li-ion electrode technology can be improved using lithium iron phosphate ($LiFePO_4$) in place of $LiCoO_2$. $LiFePO_4$ possesses increased thermal and chemical stability, charge stability for over 2000 cycles, and decreased environmental impact when discarded. In this research, Si-anode and $LiFePO_4$ technologies were simultaneously adapted to design an improved Li-ion battery. To prepare silicon for use as an anode material, Si wafers were first (metal-assisted) chemically etched, to create nanoscale channels on the surface. These channels provide space for the crystal to safely expand and contract without damage to its structure. Lithium-ion batteries, including etched, nanostructured Si-anodes, were assembled, and compared to a standard CR2032 cell at low-load conditions (10ohm resistance). The new Si-$LiFePO_4$ design demonstrated 48% higher specific capacity, and exhibited 250X improvement in consistent output, suggesting that they are better-suited than the CR2032 for long-term applications such as pacemakers, emergency lighting, and devices which require consistent power.