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In Situ Chemical Chelation And Polymer Cyclization Leading To Extremely Stable Lithium-Ion Batteries

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Silicon has the potential to revolutionize the energy storage capacities of lithium ion batteries to meet the ever increasing power demands of next generation technologies. To avoid the operational stability problems of silicon-based anodes, we propose synergistic physico-chemical alteration of electrode structure during its design. This capitalizes on covalent bonding of Si nanoparticles (SiNP) with sulfur-doped graphene (SG) and with cyclized polyacrylonitrile to provide a robust nano-architecture. This occurs during in situ chemical reaction in a microscale inside the electrode material. The hierarchical structure stabilized the solid electrolyte interphase leading to superior reversible capacity of over 1000 mAh g⁻¹ for 2275 cycles. Furthermore, the nano-architected design lowered the contact of the electrolyte to the electrode leading to not only high coulombic efficiency of 99.9% but also maintaining high stability even with high electrode loading associated with 3.4 mAh cm⁻² of areal capacity. Furthermore, the structure synergy leads to facilitated lithium diffusion, which strongly supports our results. This simple, low cost, feasible, and safe approach provide new avenues for engineering electrode structure for enhanced performance.

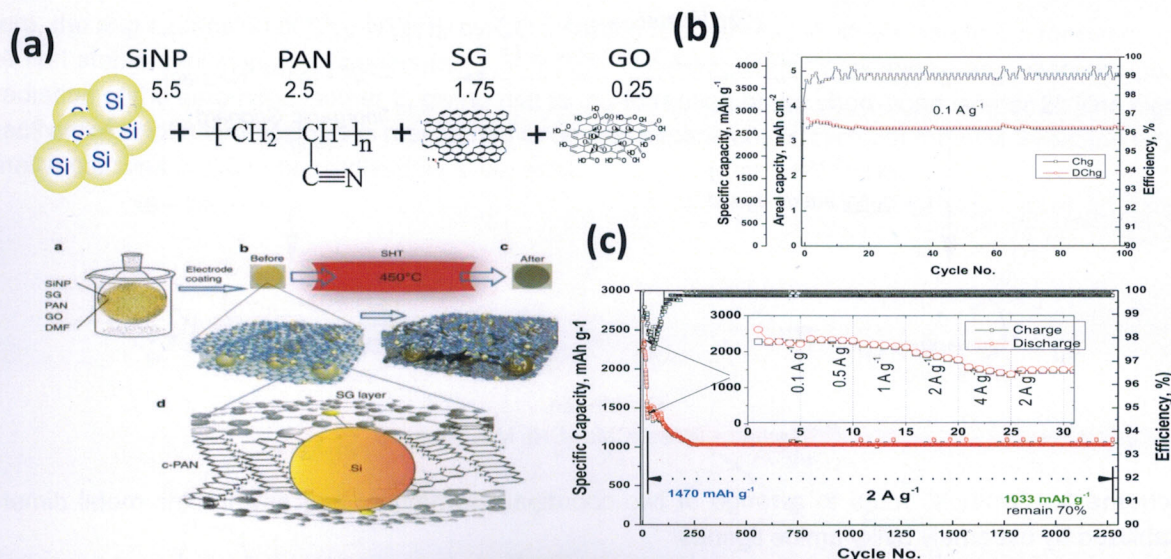


Figure 1. (a) Electrode composition and in-situ chemical chelation and polymer cyclization, (b and c) Lithium-ion battery cycle stability at 0.1A/g and 2 A/g, respectively.

1. F. M. Hassan, R. Batmaz, J. Li, X. Wang, X. Xiao, A. Yu, Z. Chen, Evidence of covalent synergy in silicon-sulfur-graphene yielding highly efficient and long-life lithium-ion batteries" *Nature Communications*, 6, (2015) 8597.
2. F. M. Hassan; A. Yu, Z. Chen, US provisional patent "A preparation method of negative electrodes for lithium ion batteries", filed on February 6, 2015, serial # 62/176,004 by USPTO