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Advancing Nanoporous Arrays: Developing a 3D NiS@Ni-Cu Electrode with Nanoporous Sphere Array through Electrodeposition for Enhanced Cycle Performance in Lithium-Ion Batteries

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Abstract : Transition metal sulfides (TMS) are recognized for their remarkable properties, which stem from their significant capacities and advantageous physicochemical traits, positioning them as promising candidates for anode materials in lithium-ion batteries (LIBs). Among these, nickel sulfide has attracted considerable interest due to its environmental sustainability, affordability, electrical conductivity, and theoretical capacity. Nonetheless, issues such as sluggish charge transport and electrode degradation resulting from volume changes necessitate further exploration to improve battery performance. This research presents a three-dimensional nanoporous NiS@Cu-Ni structure with a spherical array (3D NiS@CNSA) as a potential LIB anode material to mitigate these challenges. Utilizing a non-template constant current electrodeposition method for five minutes, a conductive network and stress-buffering architecture were established by affixing a Cu-Ni nanosphere array onto nickel foam substrates, followed by a 30-minute constant potential electrodeposition to apply NiS onto the current collector. The optimized 3D NiS@CNSA electrode demonstrated an initial reversible capacity of 2.07 mAh cm^{-2} at a current density of 0.4 mA cm^{-2}, retaining 1.92 mAh cm^{-2} after 200 cycles, which corresponds to a high capacity retention rate of 92.8%. Additionally, it displayed a rate capability of 1.98 mAh cm^{-2} at 3.2 mA cm^{-2}. This study introduces distinctive design and rapid fabrication technique for electrodes with superior cyclic performance, contributing to advancements in lithium-ion battery technology.

Keywords : galvanostatic and potentostatic electrodeposition methods, transition metal sulfides, lithium-ion battery, anode, nanoporous array structure
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