Proceedings of the Canadian Society for Mechanical Engineering International Congress
32nd Annual Conference of the Computational Fluid Dynamics Society of Canada
Canadian Society of Rheology Symposium
CSME-CFDSC-CSR 2025
May 25–28, 2025, Montréal, Québec, Canada

Advancing Nanoporous Arrays: Hierarchical NiS@Cu-Ni Nanoporous Arrays for Ultra-Stable Lithium-Ion Battery Anodes

Esayas Berhanu[1], Wenbo Liu[2]
[1]Mechanical engineering, Sichuan University, Chengdu, China
[2]Mechanical engineering, Sichuan University, Chengdu, China

ABSTRACT

Transition metal sulfides have emerged as promising high-capacity anode materials for lithium-ion batteries, though their practical application is hindered by structural instability and poor charge transfer kinetics. This study demonstrates a breakthrough three-dimensional nanoporous NiS@Cu-Ni electrode featuring vertically aligned column arrays (3D NiS@CNCA) fabricated through a hierarchical electrodeposition strategy. The unique architecture comprises conductive Cu-Ni nanoporous columns grown directly on nickel foam current collectors, providing continuous electron pathways, while the conformal NiS coating enables efficient lithium-ion storage. Structural characterization reveals the columnar design's critical role in accommodating volume changes during cycling. Electrochemical testing shows exceptional performance, with an initial areal capacity of 2.34 mAh cm^{-2} at 0.5 mA cm^{-2} and 92.8% capacity retention after 250 cycles. The electrode maintains 1.99 mAh cm^{-2} even at elevated current density (3.2 mA cm^{-2}), demonstrating remarkable rate capability. These results highlight how the synergistic combination of nanoporous column arrays and bimetallic conductivity networks can simultaneously address the key challenges of structural stability and charge transport in conversion-type electrode materials. The developed architecture provides a scalable template for designing high-performance energy storage devices that combine high capacity with long-term cyclability.