Mesoscale Grand Challenge or Priority Research Direction
Lithium Batteries: Composite Electrode Materials by Design

Opportunity

Integration of multi-scale and multiphase materials in battery electrodes is more art than science at present.

No single material offers high capacity, high conductivity, good interfacial stability, reversibility, low cost and safety. Composites offer the most viable engineering solution, yet there is little fundamental understanding of the meso-scale physics and chemistry at electrodes and their interfaces.

Meso Challenge

The challenge is to identify key properties of the composite matrix that control macroscopic properties & performance of batteries.

Approach

Study the chemical and physical interactions within the composite matrix (mirco/nano particles, binders) and between the matrix, current collector, and electrolyte.

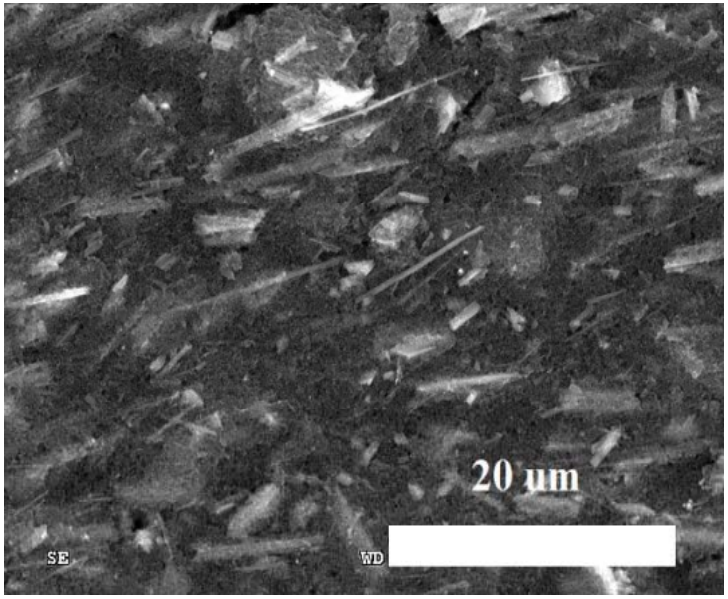
In-situ methods have the greatest potential to capture the dynamic behavior in charge and discharge steps including interactions between multi-scale/multiphase solids, and liquids.

Impact

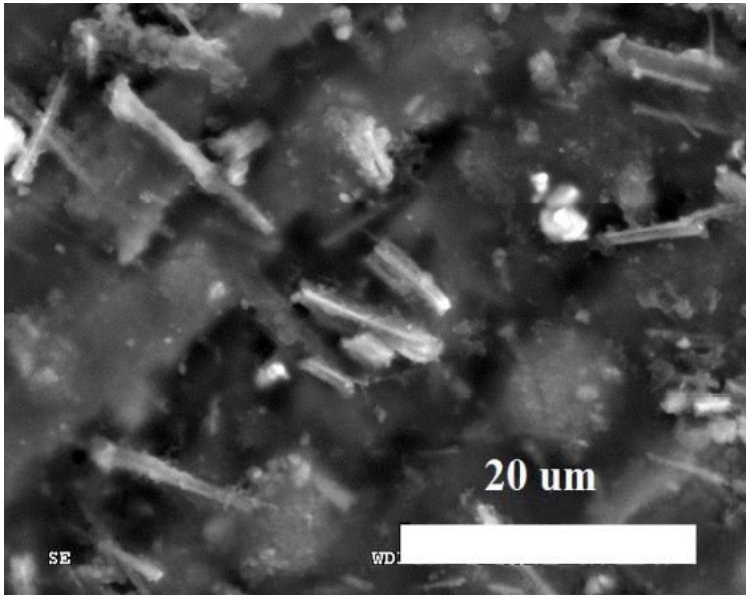
Integration of promising nanomaterials (e.g. Si nanowires, graphene) in practical batteries.

New types of batteries with the potential to displace oil as a primary energy source for transportation.

Li-Ion Composite Anodes: Active Materials including 15 % Si Nanowires & 85% Graphite



Discharged SiNW composite anodes before cycling



Charged SiNW composite anodes after cycling, SEI formation, SiNW swelling

Wanli Xu, Sri Sai S. Vegunta, John C. Flake, "Surface-modified silicon nanowire anodes for lithium-ion batteries", Journal of Power Sources 196 (20) 8583-8589 (2011), ISSN 0378-7753, DOI: 10.1016/j.jpowsour.2011.05.059.

Wanli Xu and John C. Flake, "Composite Silicon Nanowire Anodes for Secondary Lithium-Ion Cells", Journal of The Electrochemical