Improving Low-Temperature Performance of Battery Anodes Based on Surface-Controlled Charge Storage Mechanism

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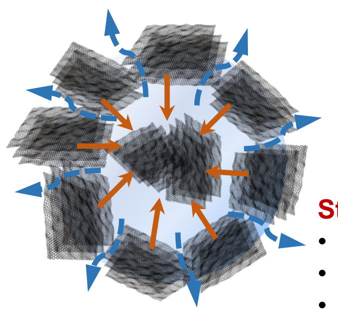
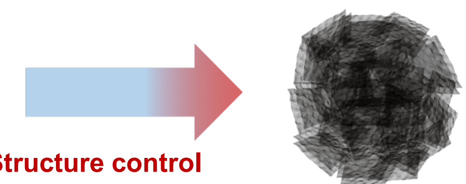
Research Objectives

- **Goal:** To design a high-performance and stable anode to enable battery operation in extreme cold environments.
- **Key Innovation:** The synthesis of the structure-controlled 3D graphene assembly though stacking engineering, which can effectively utilize the surface-controlled mechanism.
- **Compared to SOA:** Surface-controlled charge storage mechanism on the graphene anode can be much faster and safer over SOA anodes based on diffusion-controlled charge storage mechanism.
- **TRLs:** We plan to transition from current TRL 2, given advanced graphene anode concept, to TRL 3 through high-performance anode development with extensive performance assessment.

Stacking-Engineering of Graphene Sheets



Structure-Controlled 3D Graphene Assembly



Structure control
- Packing density
- Pore structure/surface area
- Degree of stacking

Mechanism
- Surface-controlled charge vs diffusion-controlled charge storage processes

Performance
- Enhanced rate-capability
- Ultra-long cycling stability
- Stable SEI formation
- Prevention of Li-plating

Designing Faster- and Safer-Anode in Extreme Cold Environments

Approach

- Our unique approach is to use the stacking engineering process that can control the structure of the assembled graphene electrodes, such as assembly shape and size, pore structure, degree of stacking, and packing density.
- We will 1) assemble structured-controlled graphene anodes through stacking engineering, 2) investigate their charge storage mechanism and performance, 3) assess the cycling stability and associated structural change at low-temperature operation, and 4) establish the structure-mechanism-(low-temperature) performance relationship, to identify the ideal structure that has superior charge storage performance in extreme cold environments.

Potential Impact

- Advanced battery based on the graphene anode will be one of the key enabling technologies supporting the entire spectrum of NASA's human space exploration and science missions from low earth orbital to Mars surface in extremely cold environments.
- We will add to the knowledge base of the assembly of electrodes, the energy storage mechanisms, and the assessment of performance limit of batteries, which can provide general insights for designing many other energy storage devices, including supercapacitors, for NASA's use.