Faculty of Science and Engineering

2021 Australian Government Research Training Program Scholarships

Strategic Project Profile

PROJECT TITLE: Design of cathode-electrolyte interface towards better solid-state lithium batteries

FIELD OF RESEARCH CODE: 0904

PROJECT SYNOPSIS:

Background

Energy security is critical to Australia’s social stability; human and intellectual capital and technological solutions are required to sustain Australia’s economic growth and strengths. The development of advanced energy storage system can circumvent the intermittency issue associated with the use of renewable energy sources and thus constitute a more reliable energy grid system in Australia. Lithium batteries have long achieved practical use since the 1990s. Development of new electric applications powered by lithium batteries could further take advantage of the abundant lithium resources in Australia, especially in Western Australia.
Utilising solid-state electrolytes (SSEs) could eliminate the danger associated with the liquid electrolytes which are flammable in nature, and could also inhibit the lithium dendrite piercing that can cause unexpected short circuits. However, interface/boundary resistances of the electrolytes inevitably cause a decrease of the energy density of lithium batteries.

Aims

This project is one of the core parts of Prof. Zongping Shao’s Australian Research Council Discovery Project (Interface/Boundary Engineering Towards Better Solid-State Lithium Batteries) which commenced in 2020. This project aims to develop high-performance solid-state lithium batteries by engineering the design of interfaces between the cathode and electrolyte. A novel cation exsolution strategy will be proposed and investigate for the first time for optimising the surface of solid-state electrolyte. Based on this core strategy, a dense solid-oxide electrolyte decorated with functional nanoparticles will be developed and further modified to afford high electronic and ionic conductivity of cathode-electrolyte interfaces and good capability for buffering the volume change of the cathode. This project will also aim to develop optimised cathode architectures for achieving higher energy density and power output of the solid-state batteries.

Objectives

1. Investigation of a novel cation exsolution strategy for developing oxide-based solid-state electrolytes decorated with nanoparticles.
2. Construct a cathode-electrolyte interface by rational designs on the ionic and electronic transfer pathway.
3. Improving performance of solid-state lithium batteries by developing advanced cathode architectures.

A schematic of a systematic research strategy for the proposed design of cathode-electrolyte interface towards better SLBs is shown in the Figure below:

Investigators

A team of experts in complementary areas (Prof. Shao from WASM: MECE, Dr. Guohua Jia from School of Molecular and Life Sciences) and a full-time PhD student will be assembled to conduct this project. Prof. Shao and Dr. Jia will be responsible for the overall supervision of the project. Prof. Shao has expertise in designing functional oxide materials for energy storage and conversion systems. Dr. Jia will provide primary advice and expertise in the nanomaterials synthesis and surface functionalisations. The PhD students will work on the laboratory preparation, characterisation and electrochemical performance tests of the batteries. The PhD students will also be required to prepare publications, reports, and thesis.

Timeline

This is a three-year project, starting from August 2020 with the following activities:
Significance and Expected Outcomes

This project falls into the Science and Research Priority of Energy of Australia. Our focus on the development of SLBs can circumvent the intermittency issue associated with the use of renewable energy sources and thus constitute a more reliable energy grid system in Australia. It can help boost the prosperity of Australia’s lithium mining industry, especially in Western Australia which has long been recognized as a battery metal powerhouse. The completion of this project will add to the fundamental understanding of a more powerful and safer solid-state lithium battery based on the optimisation of interface, which may inspire evolutilional breakthroughs in lithium battery technologies.

FEASIBILITY AND RESOURCING – DESCRIPTION OF THE SUPPORT THIS PROJECT WILL RECEIVE:

This project is based on Prof. Shao’s expertise in the rational design of functional oxide materials as solid-state ionic conductors. Shao has built an outstanding laboratory for batteries, fuel cells and other advanced energy technologies. The WASM: MECE has invested significantly in infrastructure and equipment for fabrication, characterisation and testing of batteries (e.g., Ar-filled glove box, high temperature furnaces). Characterisation facilities (e.g., SEM, TEM, XRD, XPS) available at Curtin University can be easily accessed by the members of this project. Prof. Shao has also established collaborations with world-leading researchers on advanced solid ceramic preparation and ex-situ/operando characterisations.

THE SIGNIFICANCE OF THE PROJECT/ PROGRAM FOR THE ENROLLING SCHOOL OR INSTITUTION:

The project proposes a comprehensive engineering design of the boundary of the solid-electrolyte and the interfaces between electrolyte and electrodes by excellently integrating advanced materials screening, synthesis, characterisation and electrochemical result interpretation. Of significance, this could lead to breakthroughs in the development of novel SLBs and could contribute to the knowledge base in the field of new energy conversion
technologies for both Australian and the international community. The research outputs are also expected to promote the research capability and reputation of Faculty of Science and Engineering and Curtin University.

Students must express interest in this scholarship opportunity by emailing the Project Lead listed below. Please provide a copy of your current curriculum vitae and detail your suitability to be involved in this strategic project.

**PROJECT LEAD CONTACT:**

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