

# Design and Synthesis of Hierarchical Nanostructures for High Performance Lithium-Ion Batteries with Improved Safety

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**Abstract:** Lithium-ion batteries have come a long way from its inception to widespread deployment in a multitude of applications, ranging from micro electronic devices to large scale deployment such as grid energy storage and electric vehicles. However, the story of this technology is far from ending as technology continues to improve and demand higher portable energy storage. Despite decades of research and development, the technology remains bogged down by high cost, insufficient energy storage capacity, and safety. Motivated by these issues, the work set out in this thesis strived to contribute incremental knowledge and understanding of materials that are able to move the technology forward.

A systematic study of several novel conversion ( $\text{MoO}_2$  and  $\text{CoS}_2$ ) and alloy ( $\text{SnS}_2$  and  $\text{SnSe}_2$ ) based materials with intrinsic high lithium storage capacities was carried out. These materials were incorporated into carbonaceous materials such as CNTs and graphene through a rational design and synthesis process to obtain hierarchical nanostructured composites. The synthetic strategies proved to be successful where the composites exhibited enhanced electrochemical properties when used as anodes in Lithium-ion batteries. Regarding battery safety, thermoresponsive polymer was developed to act as an *in situ* cell shut down mechanism. At high temperatures, the polymer melts to form an insulating film that prevents further flow of Li-ions. Optimisation and improvements were made through the incorporation of thermally and electrically conductive CNTs as well as deposition of the additive via 3D printing. Through these methods, rapid battery shutdown was achieved using low additive loading.



**Speaker Bio:** Huang ZhiXiang was granted his BEng Degree in Engineering Science Programme (ESP) with a specialization in Energy Systems from National University of Singapore (NUS) in June 2013. Shortly after, he joined Airbus Singapore and Singapore University of Technology and Design (SUTD) as a PhD candidate in Engineering Product Development under the Industrial Postgraduate programme scholarship in September 2013. He is currently under the supervision of Prof Yang Hui Ying. His research interest focuses on nanostructured materials and the study of electrochemistry for energy storage applications.