QMUL/CSC STUDENTSHIP

1. Project Background and Description

Project title: **3D Sustainable Architected Electrodes for Energy Storage Devices**

Energy storage devices (batteries, supercapacitors, etc.) are essential to supporting our modern life and helping achieve the ambitious net-zero target. In these energy storage devices, one of the key components is the electrode where the chemical reaction takes place. Maximising the surface areas where electrons, reactant, and electrolyte meet and reaction can take place, is a general goal in design of electrodes for energy storage devices. The structural integrity and damage tolerance of these electrodes are also an emerging concern of designers. 3D hierarchical porous network with interconnected structure and conducting pathway and high surface area offer a great potential for improving the structural, electrochemical properties of future energy devices.

With the advance of 3D printing technologies, the flexibility to design porous electrodes with architected structures in an energy storage device has been greatly enhanced in terms of length scale and topologies. 3D printing can produce 3D porous structures with a resolution to 10 µm thick [1] and a wide range of anisotropies [2].

However, the application of 3D-printed electrodes in energy storage devices, still in its infancy, has heavily relied on extensive trial-and-error experimental approaches. The structural and electrochemical behaviours of these new electrodes are still unaddressed. This project is therefore designed to substantially address this bottleneck by unravelling the structure–property relationships in electrodes via an integrated approach of experimental and computational endeavours.

The overall aim of the project is to evaluate the mechanical and electrochemical performance of sustainable composite electrodes made from natural materials (e.g. cellulose, lignin or bio-waste). Experimental tests will be conducted to characterise the mechanical and electrochemical properties of sustainable composite electrodes. Results from experimental measurements will be used to develop an analytical or computational model to predict the mechanical and electrochemical behaviours of sustainable composite electrodes used in energy-storage devices.

2. Project Scope

- To manufacture the 3D architected electrodes for energy storage devices using 3D printing, surface modification and heat treatment.
- To characterise the structural and electrochemical behaviours of these electrodes and apply the electrodes in energy devices (e.g. redox-flow batteries, lithium-ion batteries or supercapacitors).
- To model the structural and electrochemical behaviours of these electrodes using commercial finite element software (ABAQUS, COMSOL, etc).

3. Eligibility and Applying

The deadline for applications to Queen Mary is **30th January 2022**. Applicants must be Chinese nationals and should meet our entry requirements. Applicants must first apply for our PhD programme following our usual application procedures. Applicants must first have an offer for admission to Queen Mary's PhD programme and then they should apply to CSC for the scholarship between 10th March and 31st March. Results are usually released in May. **Please send your email and CV to Dr Wei Tan and Dr Ana Sobrido for application.**

4. Desired Skills from the Student

- For students from Engineering background: good knowledge in mechanics of materials, mechanical tests or finite element analysis.
- For students from Materials Science or Chemistry background: good knowledge in electrochemistry, energy materials, 3D printing, etc.
- Excellent English communication and writing skills.
- The ability to work both independently and as part of a team.

5. Supervisors and Contacts

Primary: Dr. Wei Tan, Lecturer in Mechanical Engineering.

Email: wei.tan@qmul.ac.uk

Second Supervisor: Dr Ana Sobrido, Reader in Sustainable Energy Materials.

Email: a.sobrido@qmul.ac.uk

6. References

[1] A.B. Jorge, R. Jervis, A.P. Periasamy, M. Qiao, J. Feng, L.N. Tran, M.M. Titirici, 3D Carbon Materials for Efficient Oxygen and Hydrogen Electrocatalysis, Adv. Energy Mater. 10 (2020). https://doi.org/10.1002/AENM.201902494.

[2] H. Kansara, G. Koh, M. Varghese, J.Z.X. Luk, E.F. Gomez, S. Kumar, H. Zhang, E. Martínez-Pañeda, W. Tan, Data-driven modelling of scalable spinodoid structures for energy absorption, in: UK Assoc. Comput. Mech. Conf. 2021, 2021.