The HKUST Energy Institute 香港科大能源研究院

EI Seminar

How to Make Hydrogen Fuel Cells Cheaper and More Efficient?

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Time 3– 4 pm
Venue Room 2405 (Lifts 17-18), HKUST **(Location)**

Abstract

Low-cost, high-performances and durable hydrogen fuel cells are crucial for the success of the global hydrogen economy and of Australia's hydrogen roadmap. Currently, researchers are attempting to reduce the reliance of scarce and expensive platinum by synthesizing low-cost alternatives using non-precious metals (such as Fe, Mn, Co). Fe–N–C structures containing Fe-N_x active sites are amongst the most promising platinum group metal-free catalysts for the oxygen reduction reaction. However, despite narrowly closing the gap in half-wave potential in rotating disk electrode over the last decade, their highest performances and durability are inferior to commercial Pt in real hydrogen fuel cells, suggesting device-level challenges.

In this talk, we shed light on this gap using the distribution of relaxation times and X-ray computed tomography to quantify the proton transport and oxygen reduction reaction kinetics of a high-performance Fe–N–C catalyst (1.08 W cm^{-2}) and a commercial platinum catalyst (1.7 W cm^{-2}) in hydrogen fuel cells. Our work reveals that the slower proton transport and oxygen reduction reaction kinetics of Fe–N–C nanoporous carbon matrix considerably limits active site accessibility, unlike easily accessible Pt decorated on a carbon substrate. We also investigated the catalyst degradations and discovered that after the loss of electrochemical active iron sites, carbon corrosion and ionomer degradation sharply reduce the catalyst layer utilization and cause a slow performance decay. Furthermore, we introduced the largest super-resolved digital twin of the hydrogen fuel cell structure, allowing to visualize large scale (> 15 mm^2) water management challenges using Lattice-Boltzmann simulations (Nature Communications, *in press*). This easily tuneable model will be crucial to further optimize the gas diffusion electrode and flow field structure to improve gas and water pathways to the active sites of high-loading non-precious metal catalysts.

About the Speaker

Dr Quentin Meyer obtained a master's degree in Electrochemical Engineering and in Electrochemical Research in 2011 from the Grenoble Institute of Technology (Grenoble-INP, Grenoble, France). He defended his PhD in *Advanced Diagnosis for Proton Exchange Membrane Fuel Cells* in 2015 working for Prof Dan Brett and awarded with an Award for Research Excellence (University College London, London UK). After a successful post-doctoral position in 3-D imaging of hydrogen fuel cells in University College London, he then relocated to Australia in 2017. Following some consultancy, teaching emerging start-ups hydrogen fuel cells and lithium-ion battery engineering, he joined Prof Zhao's group as senior post-doctoral researcher and laboratory manager (>20 people) in the University of New South Wales (Sydney, Australia). After setting-up the new hydrogen laboratory and helping secure research funding, he currently leads the exciting hydrogen fuel cells cluster. His research topics deal with electrocatalysis of complex reactions, focusing on the structure-to-performance relationships, investigating the activity and durability of low-cost electro catalysts for fuel cell and electrolyser applications. He was one of the winners of the EDRACI - Young Electrochemist Award for the Australia – New Zealand region in February 2021. Until April 2023, he has published 52 journal articles, filed 1 patent, and given over 20 communications in national and international conferences and 15 invited seminars. His h-index is currently of 25.

All are Welcome