Dynamic Electrochemical Phenomena at the Mesoscale

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Classically, the electrode-electrolyte interface is considered the heart of electrochemistry. More recently, the use of electrochemistry to drive bulk ion insertion (e.g., Li) has powered the battery revolution. As such, electrochemical ion insertion is also extensively studied as a bulk phenomena, which also has applications in advanced computing (e.g., ionic memory devices) and dynamic tuning of functional materials (e.g., electrochromics). Bridging the length-scale gap between interfaces and bulk is the fascinating mesoscale (tens to hundreds of nanometers). It is an under-investigated length scale in electrochemistry, yet it is the length of particles, the building block of porous electrodes. In this talk, I will provide an overview of emergent electrochemical phenomena at the mesoscale, focusing on how lithium intercalation take place in a many-particle ensemble. Breakthroughs in operando microscopy techniques have led to unexpected observations such as mosaic inter-particle phase separation, metastable solid-solution and fictious phase separation. These behaviors can be rationalized by carefully considering the competition between bulk and interfacial free energy, as well as between reaction and diffusion kinetics. With these fundamental insights at hand, we can finally explain mesoscale phenomena in terms of fundamental thermodynamics and kinetics rather than in terms of unexplained heterogeneities, providing practical design rules on engineering more uniform electrochemical devices.

Bio: Will Chueh is an Associate Professor in the Department of Materials Science and Engineering, a Senior Fellow of the Precourt Institute for Energy at Stanford University, and a faculty scientist at SLAC National Accelerator Laboratory. He leads a group of more than thirty researchers tackling the challenge of decarbonizing various energy transformation pathways, and co-directs Stanford's StorageX Initiative that builds academic-industrial partnerships to accelerate the electrification of transportation and the penetration of intermittent renewable electricity in energy systems. He received his BS in applied physics, and his MS and PhD in materials science from Caltech. Prior to joining Stanford in 2012, he was a Distinguished Truman Fellow at Sandia National Laboratories. Chueh has received numerous honors, including the MRS Outstanding Young Investigator Award (2018), Volkswagen/BASF Science Award Electrochemistry (2016), Camille Dreyfus Teacher-Scholar Award (2016), Sloan Research Fellowship (2016), NSF CAREER Award (2015), Solid State Ionics Young Scientist Award (2013), Caltech Demetriades-Tsafka-Kokkalis Prize in Energy (2012), and the American Ceramics Society Diamond Award (2008). In 2012, he was named as one of the “Top 35 Innovators Under the Age of 35” by MIT’s Technology Review.