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The importance of electrochemical materials science for harnessing green energy

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The intermittence of green energy such as wind and solar mandates efficient large-scale storage to replace fossil energy. Electrochemical processes enable energy storage and conversion in electrolyzers, fuel cells and batteries, particularly metal-air batteries. A highly fruitful strategy for improving the performance of these devices has been the fundamental insight derived from structure-property relationships of the active materials. Yet, these insights are predominantly based on ex situ investigations. Moreover, the mechanisms of degradation, charge transfer and bond formation are insufficiently understood, which thwarts targeted progress by materials design. More accurate structure-property relationships and elucidation of the mechanisms require innovative spectroscopic and microscopic experiments during reaction conditions. Especially, the making or breaking of the dioxygen bond hinders the efficient production of any sustainable fuel and relates to the stability of electrocatalyst materials as well as battery materials. I will firstly provide an overview on the state-of-the-art structure-property relationships of earth-abundant oxides for the electrocatalysis of oxygen and secondly highlight recent collaborative in situ work using X-ray absorption spectroscopy (XAS), particular using soft X-rays, and environmental electron transmission spectroscopy (ETEM). These experiments provide access to the active state of the materials during reaction conditions and emphasize that the active state can differ drastically from the as-synthesized material. My examples illustrate that surfaces respond dynamically to changing environmental conditions and applied fields. The talk will be concluded with the key challenges for mechanistic insight and an outlook on the future prospects of spectroscopy and microscopy during electrochemical and electrocatalytic processes on defined surfaces.

Biography

Dr. Marcel Risch leads a group at the Institute of Materials Physics at the University of Goettingen. He earned his PhD degree in Experimental Physics at Free University Berlin and subsequently performed postdoctoral work at the Massachusetts Institute of Technology at the electrochemical energy lab. He is enthusiastic about unraveling fundamental relationships between oxide physics and catalytic mechanisms that are relevant to energy storage and conversion processes in electrolyzers, fuel cells and metal-air batteries. Development of operando methods is a cornerstone of his research efforts. He authored 45 manuscripts and his work was cited more than 4200 times in total. His research has previously been awarded with the IAAM Scientist Medal 2018, the Hans-Jürgen-Engell Prize of the ISE and the Carl-Ramsauer Award of the Physical Society of Berlin.

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