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DESIGNER ELECTROCATALYSTS FROM TRANSITION METAL OXIDE HETEROSTRUCTURES

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One of the largest cost and efficiency limitations of electrochemical energy storage and conversion devices such as fuel cells, electrolyzers and metal-air batteries lies in the sluggish kinetics of the oxygen electrochemical reactions. To increase the reaction kinetics and reduce the inefficiency, it is essential to find electrocatalysts that can facilitate and catalyze these electrochemical processes. Developing a “design” principle that links material structure and chemistry to the catalytic activity can accelerate the search for highly active electrocatalyst that is cost effective and abundant in nature. In this contribution, we present our effort in establishing this structure-activity connection using transition metal oxide heterostructures as a model system. Our transition metal oxide heterostructures are grown using a layer-by-layer method and are used to examine how the surface and the sub-surface structure and chemistry can influence the oxygen reduction and evolution reaction kinetics. To reveal the origin of the structure-activity relationship, we further subject these transition-metal containing heterostructures to ambient pressure X-ray photoelectron spectroscopy to study the physical-chemical consequence of these surface/sub-surface controls. We combine this information to reveal insights into how to tune the transition-metal oxide heterostructures catalysts to facilitate the electrocatalysis and the underlying mechanism of the oxygen electrochemical reaction.