Design of highly active and durable electrocatalysts by tuning nanostructure

Yijin Kang, Dongguo Li, Nenad M. Markovic, Vojislav R. Stamenkovic

Chemical-electrical energy conversion and storage are greatly attractive for the development of sustainable energy. Among the chemical-electrical energy conversion devices, polymer electrolyte membrane fuel cell (PEMFC) is one promising technology for portable applications, from as small as portable electronics, to as large as automobiles. One key for PEMFCs is the electrocatalyst. Development of high-performance electrocatalyst nanomaterials relies on tuning material structures at nanoscale. This is in particular manifested in the design of electrocatalysts demanding both high activity and durability. Through solution-phase-synthesis, high quality nanocrystals are prepared at various morphologies (shape-controlled) and compositions (composition-controlled). The nanostructure (i.e. selective exposing specific low-index surface, controlling core-shell structure, and etc.) of nanocrystals are also carefully tuned. Moreover, binary nanocrystal superlattices offer new opportunity to explore electrocatalysis by incorporating physical and chemical properties of different materials in one single, crystalline, and complex nanostructure. Using these highly controlled nanocrystals and nanostructures as research platforms, we explore the correlation between nanostructure and activity (and/or durability). Herein, a group of high performance electrocatalysts are developed for various electrocatalytic processes, including oxygen reduction reaction (ORR) and hydrogen evolution reaction (HER). It is well-demonstrated that the careful manipulation of nanostructure of electrocatalysts is crucial to improve the activity and durability.