Sonderseminar

Freitag, 8. Februar 2019
13:00 Uhr

WSI, Seminarraum S 101

"Nanoscale electrical, mechanical and electrochemical imaging of photocathodes for hydrogen evolution reaction"

In a photoelectrochemical water splitting device, nanoparticles (NPs) are widely used as catalysts deposited onto the surface of semiconductor light absorbers. The local differences in structural, mechanical, electrical, and/or electrochemical properties at the interface all together account for the reactivity heterogeneity of materials on nanoscale, which has a significant impact on their macroscopic performances. Understanding these interfacial properties at the single-particle level is crucial for optimizing the device performance, which, however, remains poorly investigated.

Electroless plating is a facile and economic way to deposit metal catalyst nanoparticles onto semiconductor electrode surfaces, e.g. Pt/p-Si photocathodes for H2 evolution reaction. We used a combination of scanning probe methods to study the interfacial properties of Pt/Si electrodes prepared from electroless deposition. Atomic force microscopy (AFM) shows particles are highly dispersed in size and randomly scatter on the electrode surface. Conductive-AFM (C-AFM) confirms resistive Pt/Si contacts due to the presence of interfacial oxide. The conductivity is highly inhomogeneous among particles. Local current-voltage measurement revealed rectifying Pt/p-Si junctions. Nano manipulation using a stiff probe with > 5 μN force failed to push away the particles from the surface.

We performed *in situ* studies in electrolyte. An AFM-based scanning electrochemical microscope (SECM) combined with a nanoelectrode probe was used. The nanoelectrode probe had an exposed Pt-coated tip apex of ~200 nm height and the end tip radius of ~25 nm. Integrated with the multimodal PeakForce imaging, an off-resonance tapping AFM imaging mode, PeakForce SECM allows simultaneously nanoelectrical, mechanical, and electrochemical mapping. Our results show that the interfacial mechanics were greatly weakened; even a 2.8 nN imaging force removed the particles from the surface in liquid. This allows one to directly visualize the interfacial structures after the particle was removed. The junction behaviors were also altered. The conductivity inhomogeneity on Pt/Si contact among particles remains while AFM-SECM also allowed correlating the interfacial conductivity with electrochemical activities.

My talk will first very briefly discuss the recent progress in AFM techniques for solar fuel research. Following that, I will focus on the topic mentioned above, which is also a good example about the application of a broad array of advanced AFM approaches for energy research.

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