Synergism of Buried Junction and Hot-Electron Injection Effects Accelerated Charge Separation in Cu_2O Photocathode for Photoelectrochemical Water Splitting

Yu-Chang Lin (林佑錩)[1, 2], San-Yuan Chen (陳三元)[1, 3], Yan-Gu Lin (林彥谷)[2*]

[1] Department of Materials Science and Engineering, National Chiao Tung University, Hsinchu 300, Taiwan
[2] Scientific Research Division, National Synchrotron Radiation Research Center, Hsinchu 300, Taiwan
[3] Frontier Research Center on Fundamental and Applied Sciences of Matters, National Tsing Hua University, Hsinchu, Taiwan

*e-mail: lin.yg@nsrrc.org.tw

Abstract

For photocathodes, cuprous oxide (Cu_2O) has the potential to be a powerful material used to produce hydrogen via solar water splitting due to its abundance on earth and ideal band gap energy for solar energy harvesting. However, Cu_2O has not been able to reach its optimal efficiency due to its poor photostability and poor charge carrier density and mobility. Plasmon-assisted photocatalytic water splitting leads to lower overpotentials by unlocking unique mechanistic pathways. The strongly localized near fields at the surface of plasmonic nanoparticles can promote electron-hole pair generation in nearby semiconductors. Plasmon decay generates an excited hot electron which can be transferred to a surface molecule for direct reduction or injected into an adjacent wide band gap catalyst, effectively limiting carrier recombination through charge separation and expanding the usable portion of the solar spectrum. The electron dynamics in an irradiated plasmonic nanoparticle can alter the electronic coupling with surface adsorbed water and reaction intermediates, thereby changing the binding energy of these species and the catalytic properties of the plasmonic metals. To take advantage of plasmonic catalysis, alloy with strong plasmonic and photocatalytic behaviour have been synthesized in this work. Photoelectrodes' surface chemistry, structural, optical, electrical, photoelectrochemical, dimensionality effects and interfacial electronic structure along with their efficiency have been thoroughly investigated at synchrotron radiation facilities.

Keywords - Cuprous Oxide, Photoelectrochemical Water Splitting, Synchrotron X-ray techniques.