Electrocatalytic hydrogen evolution reaction of MX$_2$ and MX$_2$ heterostructures

Yanfeng Zhang*

Department of Materials Science and Engineering, College of Engineering, Peking University, Beijing 100871, China

Corresponding Author. Email: yanfengzhang@pku.edu.cn

Received: 02 June 2017, Accepted: 16 June 2017, Published Online: 14 October 2017


Abstract

Advanced materials for electrocatalytic and photoelectrochemical water splitting are central to the area of renewable energy. Recently, two dimensional layered materials of MX$_2$ (M: Mo, W; X:S, Se, etc.) have emerged as a new kind of catalysts for such applications. Our group have reported the direct synthesis of high-quality, domain size tunable, strictly monolayer MoS$_2$ flakes on commercially available Au foils by a chemical vapor deposition (CVD) method. The nano-sized triangular MoS$_2$ flakes on Au foils are proven to be excellent electrocatalysts for hydrogen evolution reaction (HER), featured by a rather low Tafel slope (61 mV/dec) and a relative high exchange current density (38.1 μA/cm$^2$). The excellent electron coupling between MoS$_2$ and Au foils is considered to account for the extraordinary HER activity [1]. Furthermore, via a facile all-CVD approach, we have also demonstrated the direct growth of monolayer MoS$_2$ on graphene (MoS$_2$/Gr) over Au foils [2,3]. A dramatic decrease of the bandgap from $\sim$2.20 to $\sim$0.30 eV was detected at the domain edge of MoS$_2$ within a lateral distance of $\sim$6 nm, as evidenced by STM/STS observations. The edges of monolayer MoS$_2$ nano-sheets were thus served as narrow-gap quantum wires, which can greatly facilitate the electrocatalytic property of MoS$_2$ in HER [4]. Meanwhile, we also synthesized either MoS$_2$/WS$_2$ or WS$_2$/MoS$_2$ vertical heterostructures on Au foils by a growth-temperature-mediated, selective two-step CVD strategy. Relative enhancement or reduction in the photocatalytic activities were observed for MoS$_2$/WS$_2$ and WS$_2$/MoS$_2$ in HER under illumination, respectively. This is explained from the type-II band alignment of the MoS$_2$/WS$_2$ stack that enables effective electron-hole separation and fast electron transfer kinetics, as well as directional electron flow from electrode to catalytically active sites [5]. The abovementioned efforts are expected to establish the internal relationship between the metallic edge states of MoS$_2$ and its HER performances, as well as the advantage of MX$_2$/MX$_2$ vertical stacks in photocatalytic HER applications.

References


Open Access

This article is licensed under a Creative Commons Attribution 4.0 International License. © The Author(s) 2017