Lin Jia, Ruichun Luo, Xiaoyu Zheng, Ping Wang, Lu Lv, Longyi Fu, Weikang Dong, Chunyu Zhao, Dian Li, Minghui Li, Jing Li, Yang Yang, Denan Kong, Jijian Liu, Qingmei Hu, Yang Zhao, Yan Xiong, Wu Zhou*, Jiadong Zhou*, Yao Zhou*

Beijing Institute of Technology. Beijing. China
email: jialin@bit.edu.cn

Mixing entropy engineering is a promising strategy to tune the physical and chemical properties of materials. Although high-entropy in van der Waals bulk solids have been reported, entropy engineering in 2D monolayer remains unconquered. In this work, we report the epitaxial growth of 2-inch 1T" hexanary medium-entropy alloy monolayers ($Re_aW_bMo_cIn_dS_xSe_y$) via chemical vapor deposition method. The atomic structure and chemical composition are confirmed by X-ray photoelectron spectroscopy, scanning transmission electron microscopy, energy dispersive X-ray spectroscopy and electron energy loss spectroscopy, illustrating the uniform distribution of the six elements. The hexanary medium-entropy alloy field-effect transistors exhibit metallic transport behavior and photodetectors show an ultrawide photo response from visible to near-infrared wavelengths with a responsivity of 110.2 A W^{-1} under 520 nm laser illumination. Meanwhile, the hexanary medium-entropy alloy monolayer exhibits excellent electrocatalytic hydrogen production with an overpotential of 176.6 mV in dark. Importantly, an overpotential of 43.7 mV at 10 mA cm^{-2} with a lowered Tafel slope of 51.9 mV dec^{-1} under 520 nm laser irradiation is obtained due to excellent electrical conductivity. Our work opens a new way to design mixing entropy alloys and realize the application of transition metal dichalcogenides (TMDs) in photo-enhanced electrocatalytic hydrogen production.