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Atomically Layer-Dependent Two-Dimensional Platinum Diselenide/Si heterojunction for Efficient Photoelectrochemical Hydrogen Production

Abstract
Harvesting solar energy for hydrogen production via photoelectrochemical (PEC) water splitting is one of the most promising ways to acquire a renewable and sustainable energy source. To realize this technology, transition-metal-based electrocatalysts have been pervasively adopted as cocatalysts to enhance the performance of PEC device for water reduction. Recently, a newly synthesized Group-10 transition metal dichalcogenides (TMDs) - platinum diselenide ($PtSe_2$) - have drawn significant attention due to its unique electrical[1], optical properties and catalytic performance[2]. This two-dimensional (2D) $PtSe_2$ shows the most remarkable layer-dependent electrical properties among various 2D materials ranging from metallic to semiconducting behaviors. Thus, it is a rising candidate for energy conversion in 2D photoelectrochemical device due to its high catalytic activity for hydrogen evolution reaction (HER). Here, we demonstrated an atomically layered CVD platinum diselenide ($PtSe_2$) thin film for a highly efficient heterogenous silicon photocathodes. Through the controlled number of layers, our results show that the 2D layered $PtSe_2$ catalysts significantly reduce the overpotential and retain a high photocurrent density. The $PtSe_2$/Si heterostructured photocathode displays an efficient PEC for hydrogen production with a low onset potential of 1 mA/cm^2 at 0.27 V versus a reversible hydrogen electrode and the high photocurrent density of 28 mA/cm^2 at 0 V. Most interesting, we clearly observe the dependence of atomic layer number of $PtSe_2$ on the corresponding PEC conversion efficiency as a result of interfacial band alignment at the $PtSe_2$/p-Si heterojunction. Our result suggests that 2D atomic layer $PtSe_2$ can act as an excellent catalyst for efficient PEC conversion for hydrogen production.

References

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Figures

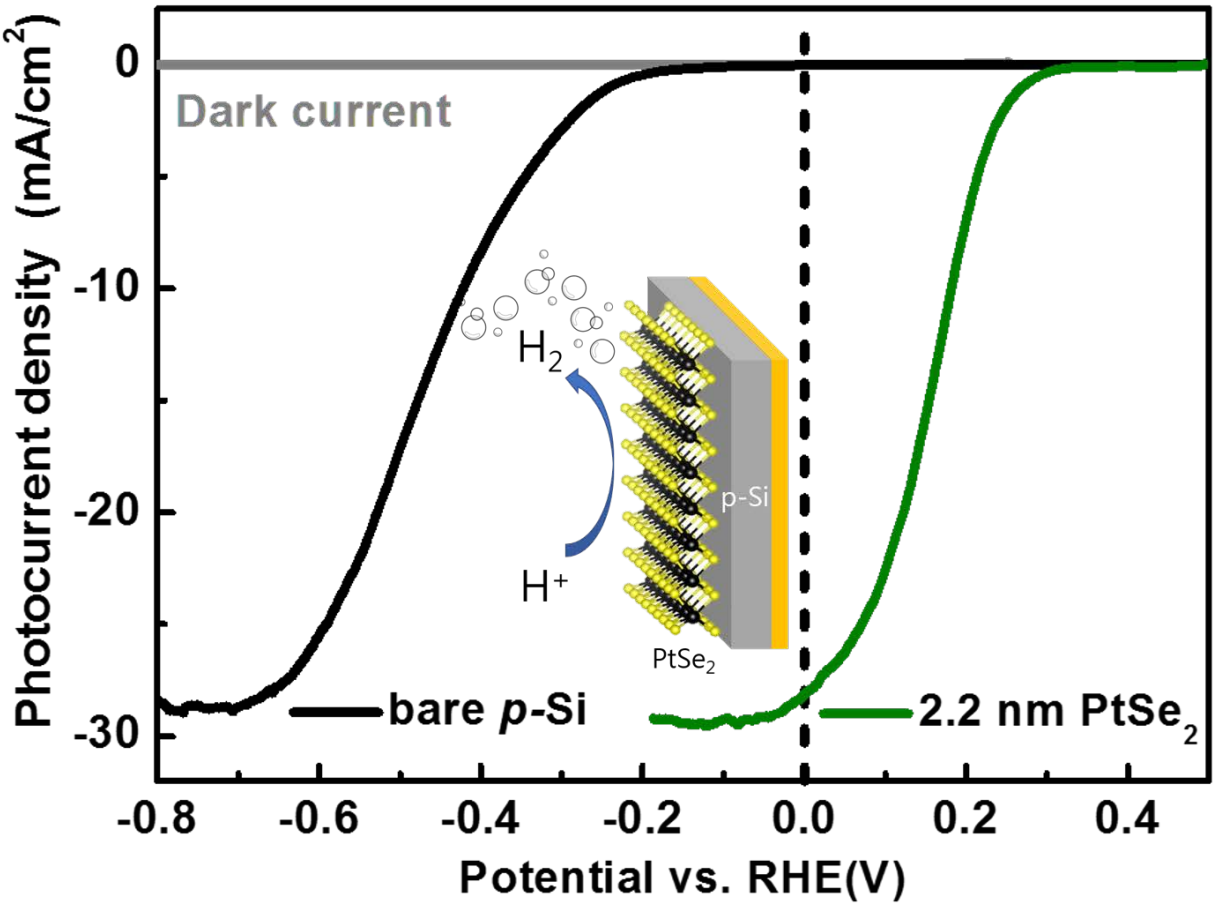

Figure 1: Schematic illustration and polarization curves of the $PtSe_2$/p-Si heterostructured photocathode.