$MoSe_2$ - a versatile transition metal dichalcogenide and heterostructures thereof for applications in catalysis and optoelectronics

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Abstract

2D nanomaterials are an exciting class of materials in themselves amongst the nanomaterials. The sheer nature of these materials being confined along one dimension and with a huge surface area in the other two dimensions leads to very exciting properties.

Transition metal dichalcogenide (TMD) nanosheets with defect-rich and vertically aligned edges are highly advantageous for various catalytic applications. Synthesis of TMDs using the colloidal techniques opens various possibilities to tune the electronic and optical properties of these 2D materials. As an example, we choose $MoSe_2$ nanosheets that have plenty of defects. The defect sites are responsible for adsorption on the surface thereby yielding excellent electrocatalytic hydrogen evolution and other catalytic activities on the surface.

Further, these defects can be employed as seeding points to grow other materials on them. Cu_2S in these defect sites leads to a Type-II semiconductor heterojunction that allows for charge separation and therefore the $MoSe_2$-Cu_2S forms a superior material for generation of photocurrent and water splitting.

Now even heterojunctions of $MoSe_2$, a hexagonal crystal with $CsPbBr_3$ – a perovskite have been enabled by use of a linker molecule 4 – aminothiophenol. Enhanced photocurrents are obtained with such a nanoheterostructure. This methodology further opens up avenues for forming heterostructures with large lattice mismatches and can therefore be of great potential use.

Another method to explore heterostructures is to use two materials that form nanosheets and therefore are capable of coming close by means of van der Waals interactions. $MoSe_2$-SnS is one such nanoheterostructure that we have also fabricated.

Keywords: transition metal dichalcogenides, water splitting, HER, OER, photocurrent

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