Solution-processed photoelectrochemical (PEC)-type photodetectors based on layered GaSe and GeSe nanoflakes

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The photoelectrochemical (PEC) devices, such as self-powered photodetectors and water splitting cells, represent powerful tools to convert the electromagnetic radiation into chemical fuels and electricity.[1] To achieve efficient PEC systems, it is mandatory to develop photocatalytic materials that efficiently absorb light in the desired spectral range (UV/visible for energy conversion systems), creating free charge carriers with suitable energies to carry out the oxidation-reduction (redox) reactions before they recombine.[2] In this context, two-dimensional (2D) materials are continually attracting utmost interest as potential advanced photo(electro)catalysts,[2] and recently, 2D group-III and group-IV transition metal monochalcogenides (MCs) have been theoretically predicted to be low-cost and eco-friendly photocatalyst. [3] Among them, gallium selenide (GaSe) and germanium selenide (GeSe), are promising material candidates for optoelectronic devices due to their properties: tuneable electronic structure, strong visible-light absorbance, photoresponse and environmental stability.[4] Here, we report the first experimental characterization of the PEC water splitting activity of single-/few-layer flakes of GaSe and GeSe produced in inks form by scalable liquid-phase exfoliation method in non-toxic solvent (*i.e.*, 2-propanol).[5] The PEC behaviour of monochalcogenides(MCs)-based photoelectrodes, obtained by spray coating approach,[6] were evaluated in different aqueous media, ranging from acidic to alkaline solutions and under different illumination wavelengths, *i.e.*, 455, 505 and 625 nm. The obtained performances (responsivity and external quantum efficiency up to 0.32 A/W and 86.3%) are superior to those of several self-powered and low-voltage solution-processed photodetectors, approaching the ones of their commercial UV–Vis counterparts. Finally, we demonstrate the use of MCs-based photoelectrodes as photoanodes or photocathodes for water splitting reactions under simulated sunlight.

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FIGURE

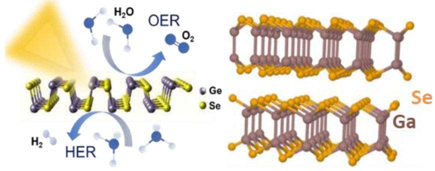

Figure: Crystal structure of monchalcogenides and schematic processes of PEC water splitting

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