Group-III layered Semiconductors (GaSe and GaS) for Photoelectrochemical (PEC)-type Photodetectors

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Layered semiconductors of group-III have attracted considerable attentions thanks to their distinctive optoelectronic and anisotropic structural properties[1]. Currently, two-dimensional (2D) gallium selenide (GaSe) and gallium sulphide (GaS) have been emerging as a promising candidate for the realization of PEC-type photodetectors[2]. A requirement for large-scale applications is the development of low-cost, reliable industrial production processes[3],[4]. In this context, liquid-phase exfoliation (LPE) methods can provide scalable production of 2D materials in form of liquid dispersion, enabling their processing in thin film through low-cost and industrially relevant deposition techniques[5]. In this study, we report the first experimental characterization of the PEC properties of single-/few-layer flakes of GaSe and GaS produced in form inks by LPE approach in green solvents (2-propanol), which has been reported to be effective for exfoliating others monochalcogenides[6]. The as-produced inks were deposited through printing techniques, *i.e.*, spray coating, to obtain solution processed self-powered PEC-type photodetectors. The PEC behaviour of GaSe-/GaS-based photoelectrodes were evaluated in different aqueous media, ranging from acidic to alkaline solutions: 0.5 M H_2SO_4 (pH 0.3), 1 M Na_2SO_4 (pH 6), 1 M KCl (pH 6.5), 1 M KOH (pH 14) under different illumination wavelengths in the UV/visible spectral range, namely 275, 455, 505 and 625 nm. GaSe photoelectrodes show a responsivity of 0.16 A W^{-1} upon 455 nm illumination at a light intensity of 63.5 µW cm^{-2} and applied potential of −0.3 V versus reversible hydrogen electrode (RHE). Meanwhile, GaS flakes can be used to realize innovative PEC-type UV-selective photodetectors. Our results open the way towards the use of 2D metal monochalcogenides in innovative PEC applications, including medical diagnostics, air purification, chemical analysis (ozone sensing) and advanced optical communications.

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FIGURES

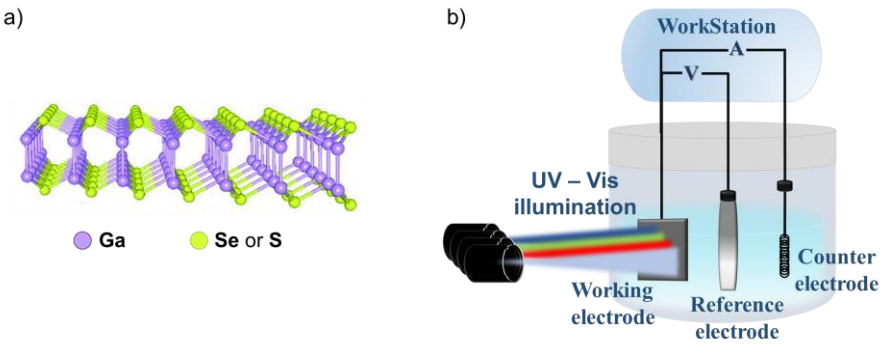

Figure 1: a) Crystal structure of monochalcogenides. b) Sketch of the experimental setup used for characterization of the PEC-type photoelectrodes.

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