

Solution-processed GaSe nanoflake-based films for photoelectrochemical water splitting

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Gallium selenide (GaSe) is a van der Waals (vdW) layered material, which can be exfoliated in two-dimensional (2D) form due to its low cleavage energy (typically $< 0.5 \text{ J m}^{-2}$) [1]. 2D GaSe has been theoretically proposed as a photocatalyst for water splitting reactions [2]. In fact, its 2D nature intrinsically guarantees that the charge carriers are directly photogenerated at the interface with the electrolyte, where redox reactions take place before their recombination [2]. Moreover, the 2D GaSe electronic structure can be tuned by controlling the number of the layers to fulfil the fundamental requirements for a water splitting photocatalysts, *i.e.*: 1) conduction band minimum (CBM) energy (E_{CBM}) $>$ reduction potential of H^+/H_2 ($E(\text{H}^+/\text{H}_2)$); 2) valence band maximum (VBM) energy (E_{VBM}) $<$ reduction potential of $\text{O}_2/\text{H}_2\text{O}$ ($E(\text{O}_2/\text{H}_2\text{O})$) [3]. In our work,[4] we have investigated for the first time the photoelectrochemical (PEC) properties of GaSe nanoflakes, produced by scalable liquid-phase exfoliation [5] in a green solvent (2-propanol) [6]. We report the remarkable photoelectrocatalytic properties of the GaSe nanoflakes for hydrogen evolution reaction (HER) and oxygen evolution reaction (OER) in both acidic (0.5 M H_2SO_4) and alkaline (1 M KOH) media. In 0.5 M H_2SO_4 , the GaSe photoelectrodes show the best PEC performance, reaching a cathodic photocurrent density at 0 V vs. RHE ($J_{0\text{V vs RHE}}$) of $-9.3 \mu\text{A cm}^{-2}$, a ratiometric power-saved metric for HER ($\Phi_{\text{saved,HER}}$) of 0.09%, an anodic photocurrent density at +1.23 V vs. RHE ($J_{1.23\text{V vs RHE}}$) of $83.4 \mu\text{A cm}^{-2}$ and a ratiometric power-saved metric for OER ($\Phi_{\text{saved,OER}}$) of 0.25%.

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FIGURE

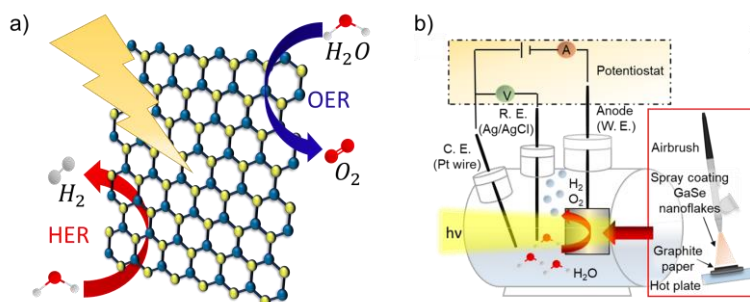


Figure 1: a) Schematic diagram of HER and OER processes. b) Schematic illustration of the experimental setup for electrochemical characterization of the GaSe photoelectrodes.