Liquid-phase exfoliated GeSe nanoflakes for photoelectrochemical-type photodetectors and photoelectrochemical water splitting

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The conversion of electromagnetic radiation into chemical fuels and electricity through photoelectrochemical (PEC) cells represents a powerful strategy for sustainable fuel and chemical generation,[1] as well as innovative self-powered photodetectors.[2] In this context, two-dimensional (2D) materials are attracting huge interest as potential advanced photo(electro)catalysts.[3] Recently, low-cost and environmentally friendly 2D group-IVA metal monochalcogenides have been theoretically predicted to be water splitting photocatalysts.[4] Among them, layered germanium selenide (GeSe), is a promising material candidate for optoelectronic devices due to its tuneable electronic structure, strong visible-light absorbance, photoresponse and environmental stability.[4] Here, we report the first experimental study of the photo(electro)catalytic activity of single-/few-layer GeSe flakes in different aqueous media, ranging from acidic to alkaline solutions: 0.5 M H_2SO_4 (pH 0.3), 1 M KCl (pH 6.5), 1 M KOH (pH 14). The PEC properties of the GeSe nanoflakes, produced by liquid-phase exfoliation approach[5] in non-toxic solvents (*e.g.*, 2-propanol) and deposited by spray-coating technique,[5] are used to conceive PEC-type photodetectors, reaching responsivity up to 0.32 AW^{-1} under 455 nm. Finally, we demonstrate the use of GeSe-based photoelectrodes as photoanodes or photocathodes for water splitting reactions under simulated sunlight, inspiring the use of 2D GeSe in innovative PEC systems.

References

[1] S. Bellani, M.R. Antognazza, F. Bonaccorso, Adv.Mater., 9, 31 (2019), 1801446.
[2] J. Zhou, L. Chen, Y. Wang, Y. He, X. Pan, and E. Xie, Nanoscale, 8 (2016), 50–73.
[3] M. I. Zappia, G. Bianca, S. Bellani, M. Serri, L. Najafi, R. Oropesa-Nuñez, B. Martín-García, D. Bouša, D. Sedmidubský, V. Pellegrini, Z. Sofer, A. Cupolillo, F. Bonaccorso, Adv. Funct. Mater., (2020), 1909572.
[4] C. Chowdhury, S. Karmakar, and A. Datta, J. Phys. Chem. C, 121, 14 (2017), 7615-7624.
[5] F. Bonaccorso, A. Bartolotta, J. N. Coleman, C. Backes, Adv. Mater., 29, 28 (2016), 6136-6166

Figure

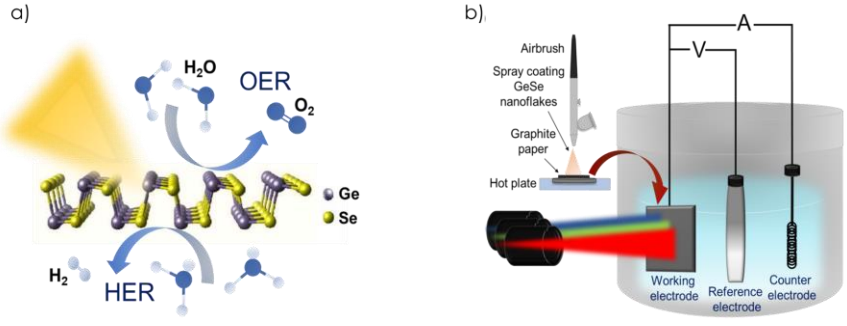

Figure 1: a) Schematic processes of photoelectrochemical water splitting on GeSe nanoflakes; b) Illustration of the experimental setup for photoelectrochemical characterization of the GeSe photoelectrodes, produced by spray coating deposition of the GeSe nanoflakes dispersion.