# Photoelectrochemical behaviour of $WSe_2$ nanoflakes: Structure-dependency and the effect Pt-decoration

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The two-dimensional (2D) semiconductors, the transition metal dichalcogenides, have received great interest during the last decade because of their high chemical stability and good electrocatalytic properties [1-2]. The photoelectrochemical (PEC) behaviour of 2D nanoflakes depends on their structural properties (the number of layers, the basal planes, and edges). Defect-rich in-planes and edges create surface states within the bandgap, which in turn act as recombination centres for the photogenerated charge carriers [3-4]. Pt nanoparticles (NPs) on 2D surfaces are considered either in a catalytic context for the PEC hydrogen evolution reaction (HER), or as passivating agent of defect states [3-4]. We need to understand the fundamental PEC properties of 2D semiconductors in the function of their structural properties, and the role of Pt NPs in defect healing using a microscopy-based approach with spatial resolution.

The $WSe_2$ nanosheets were mechanically exfoliated to get bulk, few-layered, and monolayer specimens. The $WSe_2$ nanoflakes had well-defined thicknesses as measured by atomic force microscopy (between ca. 0.9 nm and 250 nm) and the Pt NPs were deposited by a variable number of atomic layer deposition cycles. I will show our recently developed custom-designed PEC-microscope setup [5]. The deposited 5–50 µm sized microdroplet acts as an electrochemical cell on the chosen sample area of the 2D flake, which is illuminated by either white or monochromatic light. Then, I present the use of model reversible redox species to mimic photoelectrocatalytic processes, proving the differences between basal planes and edges. Additionally, I show a record high photocurrent and photon-to-electron conversion efficiency values for Pt-decorated $WSe_2$ nanoflake photocathodes applied in PEC HER. The effect of $WSe_2$ nanosheet thickness, as well as Pt surface loading was carefully quantified [6].

Finally, I demonstrate the effect of structural domains on the PEC performance of 2D $WSe_2$. i) The photocurrent losses with growing the fraction of the edges, and the parallel rise of dark currents. ii) The LPE produced $WSe_2$ bulk and few-layer nanoflakes in water reduction and oxidation, achieving only µA $cm^{-2}$ current densities. This decrease in the PEC performance can be explained by the growing of defect densities, because of the number of edge sites is increased and the area is decreased of LPE prepared nanoflakes, which means the main issue in the larger-scale application of these materials [5, 7].

References

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