# The substrate effects on the properties of single-layer $MoS_2$: enhanced Valley Helicity and enhanced HER catalytic activity

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We demonstrated that epitaxially grown single-layer $MoS_2$ on a lattice-matched GaN substrate, exhibits strong substrate-induced interactions. The phonons in GaN quickly dissipate the energy of photogenerated carriers in the $MoS_2$ through electron – phonon interaction, resulting in a short exciton lifetime and an enhanced valley helicity at room temperature (0.33 ± 0.05). The findings highlight the importance of substrate engineering for modulating the intrinsic valley carriers in ultrathin 2D materials. We also demonstrated that fractal-shaped single-layer $MoS_2$ with large tensile strain synthesized on fused silica is superior to the triangle-shaped $MoS_2$ grown on $SiO_2$ for catalyzing the hydrogen evolution reaction (HER). The optimal HER electrocatalyst of the fractal-shaped single-layer $MoS_2$, which has an edge-to-substrate ratio of about 0.33 $\mu m^{-1}$, exhibits superior HER catalytic activities, such as a low overpotential, a low Tafel slope of 45mV/dec, a large exchange current density of 50.9 $\mu A cm^{-2}$ etc. The study provides new ways to design 2D HER electrocatalysts, including controlling the geometry, strain, and modulating the electrical conductivity.

References

[1] Yi Wan, Xiang Zhang, Yu Ye*, and Lun Dai* etc., Advanced Materials, DOI: 10.1002/adma.201703888 , 2017.

[2] Yi Wan, and Lun Dai* etc., ACS Appl. Mater. Interfaces 8, 18570 (2016).

[3] Yi Wan, Yan Li*, Yu Ye*, and Lun Dai* etc., Nano Energy, accepted.

Figures

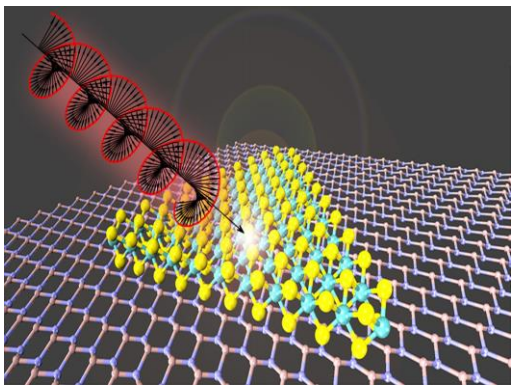

**Figure 1:** Epitaxial single-layer $MoS_2$ on GaN with enhanced valley helicity

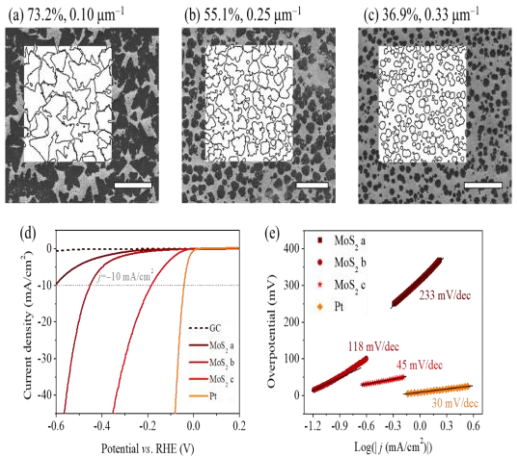


**Figure 2:** The HER catalyzing performance of the fractal-shaped single-layer $MoS_2$.