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 $\mu$Acm$^{-2}$ etc. The study provides new ways to design 2D HER electrocatalysts, including controlling the geometry, strain, and modulating the electrical conductivity.

References


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$_2$. 