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Probing the Nanoscale Excitonic Landscape and Quantum Confinement in Gated Monolayer WS2 via Cathodoluminescence

Engineering excitonic properties at the nanoscale is a central challenge in quantum photonics and optoelectronics. While far-field optical spectroscopy has greatly advanced our understanding of excitonic phenomena, its diffraction-limited resolution yields only spatially averaged information. In this work, we investigate the excitonic landscape of monolayer WS2 under electrostatic gating using cathodoluminescence (CL) spectroscopy. By leveraging the high spatial resolution of CL, we reveal a locally modulated Stark shift in exciton emission at homojunctions formed between regions with different stacking configurations. Moreover, under electron-beam excitation, we observe a gate-dependent switching of trion species, attributed to beam-induced charge trapping in the hBN dielectric. This unconventional electrostatic doping mechanism enables the formation of an exciton confinement potential, giving rise to a localized exciton channel that can be directly visualized through CL nanoscopy. Our findings elucidate the optoelectronic behavior of monolayer semiconductors under combined e-beam excitation and electrostatic gating. This approach provides a route for nanoscale exciton manipulation and opens opportunities for the control of quantum confined exciton transport in two-dimensional materials.

Topical Area

Hard matter: quantum, electronic, semiconducting materials

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