

Tailoring spectroscopic property of MoS_2 via He^+ ion Irradiation

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This study investigates the evolution of vibrational and optical properties of monolayer (ML) and few-layer (FL) molybdenum disulfide (MoS_2) under controlled He^+ ion irradiation. By varying the ion fluence, we modulate the sulfur vacancy (V_S) density in both ML and FL MoS_2 , establishing a controllable platform for defect engineering spectroscopic properties. Quantitative Raman analysis reveals pronounced shifts in the E_{2g}^1 and A_{1g} phonon modes, along with the emergence of disorder-activated modes whose intensities scale as a function of increasing He^+ ion fluence. Photoluminescence (PL) measurements show progressive quenching and spectral shifts of the A and B excitonic emissions. Notably, low-temperature PL spectra of ML MoS_2 exhibit defect-bound excitonic features approximately 200 meV below the A exciton, indicating strong exciton localization, a key prerequisite for realizing single-photon emitters (SPEs) and highly sensitive photodetectors. In contrast, FL MoS_2 does not display pronounced defect-bound PL signatures. These findings provide a controlled pathway for tailoring excitonic localization and advancing the design of MoS_2 based localized SPEs, photodetectors, and optoelectronic sensors.

References

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Figures

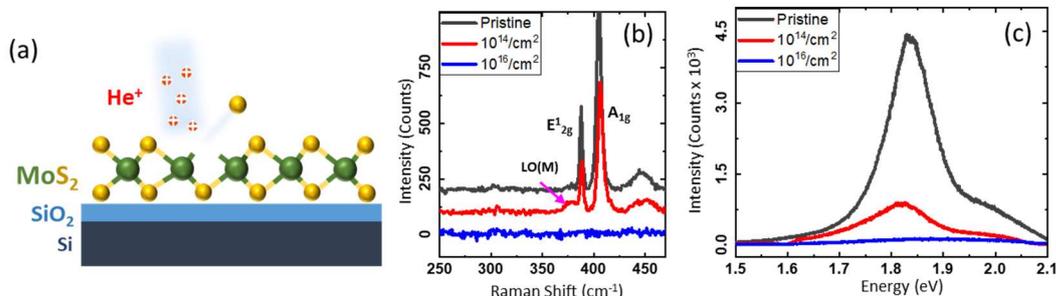


Figure 1: Structural and optical evolution of MoS_2 under He^+ irradiation. (a) Schematic illustration depicting the generation of V_S in ML MoS_2/SiO_2 via He^+ ion bombardment. (b) Evolution of Raman scattering spectra for pristine and irradiated ML MoS_2 . (c) PL spectra of ML MoS_2 as a function of ion dose, demonstrating the modification of excitonic emission profiles relative to the pristine state.

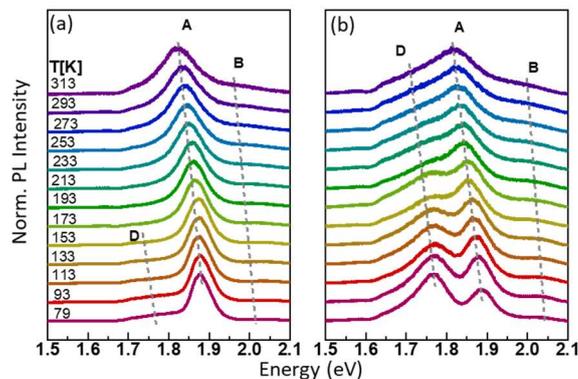


Figure 2: Temperature-dependent excitonic dynamics in ML MoS_2 . (a) PL spectra of ML MoS_2 recorded across a temperature range from 79K to 313K. Dashed lines provide guides to the eye for the peak positions of the defect-bound exciton (D), as well as the intrinsic A and B excitons, illustrating their respective thermal evolution. (b) Temperature-dependent PL spectra of ML MoS_2 irradiated at a fluence of 1×10^{14} ions/cm².