Excitonic Complexes and Defect-Localized States in Monolayer 2H-$MoTe_2$ Probed Using Photoluminescence Spectroscopy

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Abstract
Monolayer hexagonal molybdenum ditelluride (2H-$MoTe_2$) stands out in the landscape of two-dimensional (2D) semiconductors due to its strong spin-orbit coupling and near-infrared band gap (1.1 eV), making it a prime candidate for next-generation valleytronic and excitonic devices. [1] In this work, we elucidate the complex thermal evolution of excitonic species in this 2D semiconductor. Neutral exciton (A_{1s} ~ 1.19 eV) and trion (A^- ~ 1.162 eV) states are clearly resolved using temperature- and power-dependent photoluminescence (PL) spectroscopy, enabling a systematic analysis of their thermal shifts via semi-empirical and Varshni relations.[2,3] A significant localized state at ~1.132 eV, attributed to defect-bound excitons, is further revealed by power-dependent measurements, extending the spectral analysis beyond the intrinsic states. [4] By characterizing these defect-induced modifications, we provide a clearer map of the excitonic fine structure, paving the way for more robust defect-engineered devices based on transition metal dichalcogenides.

References
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[2] Juhi Pandey, Ajay Soni, Applied Surface Science, 463 (2019) 52-57
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Figures

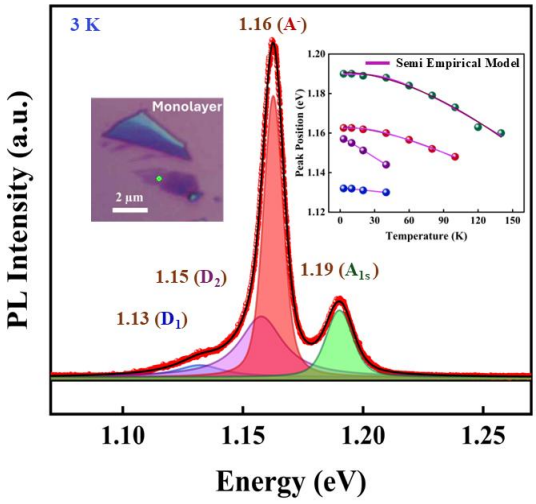

Figure 1: Low-temperature (3 K) PL spectrum of monolayer 2H-$MoTe_2$ exhibiting neutral exciton (A_{1s}), trion (A^-), D1, and D2 emissions. Insets: Optical micrograph of the exfoliated flake (left) and temperature-dependent peak evolution fitted with a semi-empirical model (right).