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## Structural and Optical Characterization of 2D Semiconductors Toward Defect-Based Quantum Sensing with Plasmonic Enhancement

Two-dimensional (2D) semiconductors such as  $WS_2$ ,  $MoSe_2$ ,  $InSe$ , and  $GaSe$  are promising materials for next generation optoelectronic and quantum technologies due to their layer dependent band structures, strong light matter interactions, and tunable defect states. Our research focuses on the structural and optical characterization of mechanically exfoliated 2D materials to understand their intrinsic and defect induced properties. Techniques such as Raman spectroscopy, photoluminescence (PL) mapping, and atomic force microscopy (AFM) are employed to correlate layer thickness and material quality with optical responses. A major objective is to explore and engineer defect centers in these layered semiconductors for quantum sensing applications. Defects can host localized electronic states enabling optically detected magnetic resonance (ODMR), similar to nitrogen vacancy (NV) centers in diamond. By controlling defect creation for coherent spin manipulation in the monolayer regime, we aim to develop atomically thin quantum sensors capable of detecting local magnetic fields with high spatial resolution. Additionally, plasmonic enhancement using gold and silver nanoparticles is being investigated to amplify optical signals. The localized surface plasmon resonances (LSPRs) significantly enhance excitation and emission intensities, improving sensitivity in optical and ODMR based measurements. This integrated approach advances nanoscale, high performance quantum sensing platforms.

### Academic or Professional Status

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