

Macroscopic Monolayer WS₂ for robust room-temperature exciton-polariton in open cavities and Honeycomb lattices

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Abstract

Conventional exfoliation of TMDCs yields 10-30 μm flakes with high variability, hindering reproducible optoelectronic studies. Artificial 2D photonic lattices, such as Honeycomb structures, offer unprecedented control over polariton dispersion and topological photonic states, yet their implementation with atomically thin materials remains challenging. Development of high-quality, large-area two-dimensional (2D) semiconductors is crucial for advancing light-matter coupling and integrated photonic devices. Here, we employ Au-assisted mechanical exfoliation to obtain monolayer WS₂ extending over hundreds of microns, and with 1-dodecanol encapsulation which passivate emission quenching. The large-area WS₂ monolayer shows high optical uniformity, providing an ideal platform for exciton-polariton research. Room-temperature strong coupling with well-defined Rabi splitting of 23 meV is achieved in open microcavities, exhibiting spectral characteristics consistent with literature reports while overcoming the heterogeneity limitations inherent to conventional exfoliation techniques. By patterning the top mirror into a honeycomb lattice, we engineer polariton bands resembling graphene, observing Dirac cones and flatbands—key signatures of polariton graphene. Our findings show that large-area monolayer semiconductors are ideal for studying unique polaritonic effects and exploring complex polariton band structures at room temperature.