Photoluminescence spectroscopy in WS_2 monolayers

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Application Note

Introduction

In the last decade, two-dimensional (2D) transition metal dichalcogenides (TMDC) have attracted a lot of attention because the same graphene protocol can be applied also to this layered compound to easily prepare atomically thin flakes. Especially, the property of materials can change drastically with the decrease of the thickness of 2D TMDCs. For example, the band gap of MoS_2 changes from indirect to direct when the 2D crystal is thinned down to a monolayer. This change of band gap results in a lot of novel properties like the great enhancement of photoluminescence (PL) and valley polarization, a unique spin texture formed in the k space of the Brillion zone, which were absent in multilayers [1]. This rich flexibility between material property and thickness makes TMDC monolayers a class of popular materials in the field of 2D materials. As one typical TMDC, the monolayer was promising for optical experiments because of its narrow direct bandgap and large quantum yield. Here, we studied the Raman Spectroscopy and photoluminescence property of monolayer.

Experimental set-up

The monolayers were fabricated by chemical vapored deposition (CVD) method [2]. The Raman and photoluminescence (PL) spectra of were measured by the Andor spectrograph Shamrock SR-500i-D1 and the Andor CCD detector iDus DV420A-OE as a function of field effect gating. The laser excitation was from a Cobalt Samba 532 nm laser.

Results

Figure 1 shows the Raman Spectrum of as-grown flakes. The E_{2g} and A_{1g} peaks were identified at 348 and 415 cm^{-1}, respectively. The insert of Figure 1 plots the PL of flake. A sharp photoluminescence peak is observed at around 632 nm. All these characteristics indicate that the monolayers grown by CVD exhibit high quality. With these monolayers, a field effect transistor using ionic liquid gating was fabricated [3].

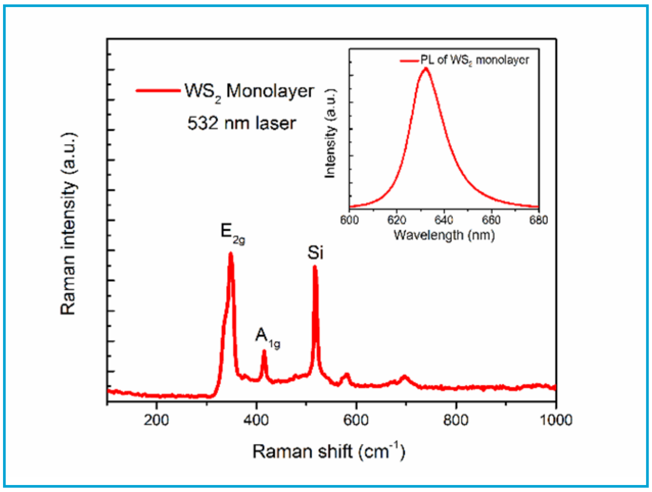
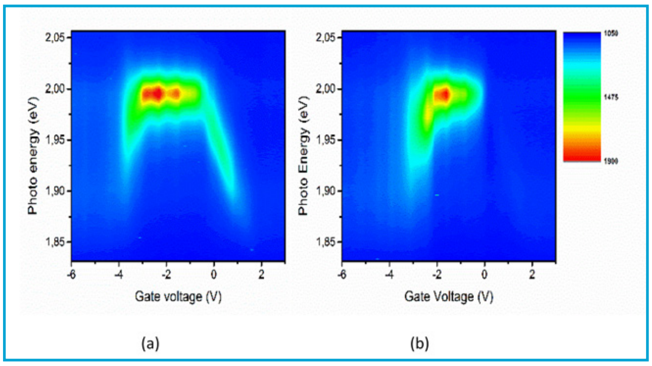


Figure 1: Raman Spectrum of monolayer. Insert, photoluminescence of monolayer

On high-quality monolayer devices, the electrical driven PL spectra at various liquid gating voltages (-6 to 3V) was tested at 220 K in vacuum. As shown in figure 2, the panel (a) and (b) correspond to the forward and back sweep of gate voltages, respectively. The gate-dependent shifting of spectra provides information about the exciton and trion formed in the electrically driven PL, which gave us a better understanding of optical properties of monolayer.



(a) (b)

Figure 2: PL spectra under electric field generated by liquid gating: (a) forward sweep, (b) back sweep

Conclusion

With the help of the Shamrock 500i spectrograph and the iDus 420 CCD detector, the Raman spectrum and the PL spectra of monolayer as a function of liquid gating voltage can be successfully characterized.

References

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