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Raman microspectroscopy of MoS_2 by uRaman

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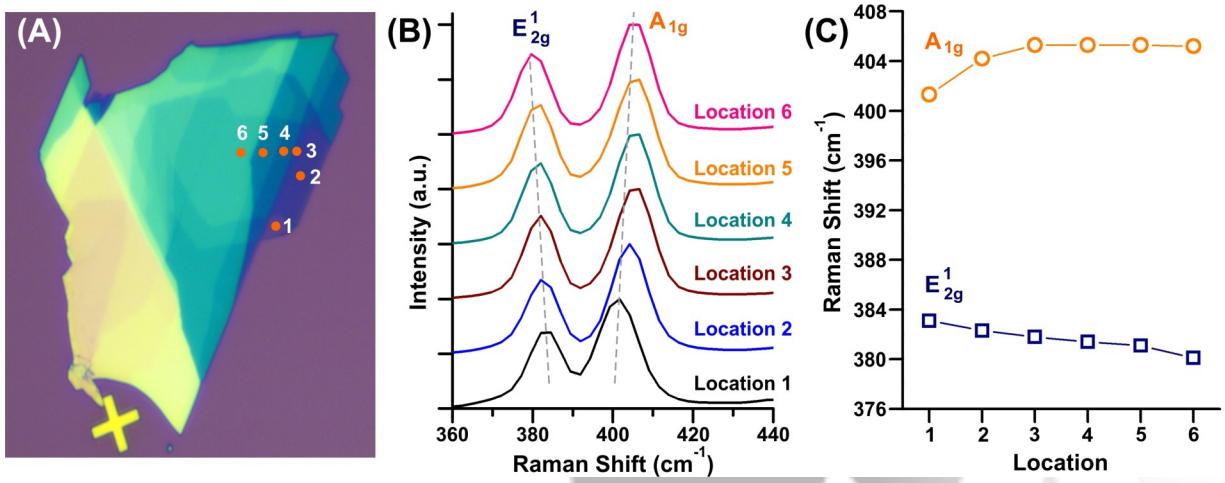
Introduction

A monolayer of molybdenium disulfide (MoS_2) has a unique and strong photoluminescence (PL) in the visible wavelength because of its direct bandgap at 1.8 eV (~680 nm). This unique characteristic makes monolayer MoS_2 a good candidate for optoelectronic application. This is unlike bulk MoS_2 with a few layers of MoS_2, which is an indirect bandgap semiconductor with reduced PL.

Raman spectroscopy is a powerful technique to assess the number of layer of 2D materials such as in graphene and MoS_2. In MoS_2, the peak separation of in-plane S-Mo-S vibration (E^1_{2g} mode) and out-of -plane vibration of S atoms (A_{1g} mode) can be used to estimate the number of layers [1,2]. We measured the MoS_2 samples using uRaman from Technospex on a Nikon-Ci body. The uRaman module consists of a compact narrow line width laser (532 nm excitation and spectra bandwidth < 1 MHz). Using diamond as a reference, the system spectral resolution was measured to yield ~ 8 cm^{-1}. Nikon 100X objective was used to measure the MoS_2 samples (model - TU Plan Fluor 100X, NA 0.9). The exfoliated MoS_2 sample was prepared by peeling a bulk MoS_2 using Scotch tape. By performing Raman spectroscopy on the exfoliated sample (Figure A), we have identified 6 different locations having different peak separations, indicating the presence of 6 different layers of MoS_2 (Figure B). The two spectra fingerprint, E^1_{2g} and A_{1g} bands, are observed at 383 and 401 cm^{-1} at location 1. As the number of layers increases, these two peaks become more separated, reaching 380 and 405 cm^{-1} at location 6 (Figure B and C). The Raman peak separation is contributed by the change in chemical interactions within the MoS_2 layers. As the layer number increases, the MoS_2 layers experience higher van der Waals force and long range Columbic interlayer interactions, which contributed to the blue shift in E^1_{2g} mode and red-shift in A_{1g} peak.



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Reference: [1] ACS Nano 2010, 4, 2695; [2] Adv. Funct. Mater., 2012, 22, 1385.

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