Electronic Supplementary Information

Phonon and Raman scattering of two-dimensional transition metal dichalcogenides from monolayer, multilayer to bulk material

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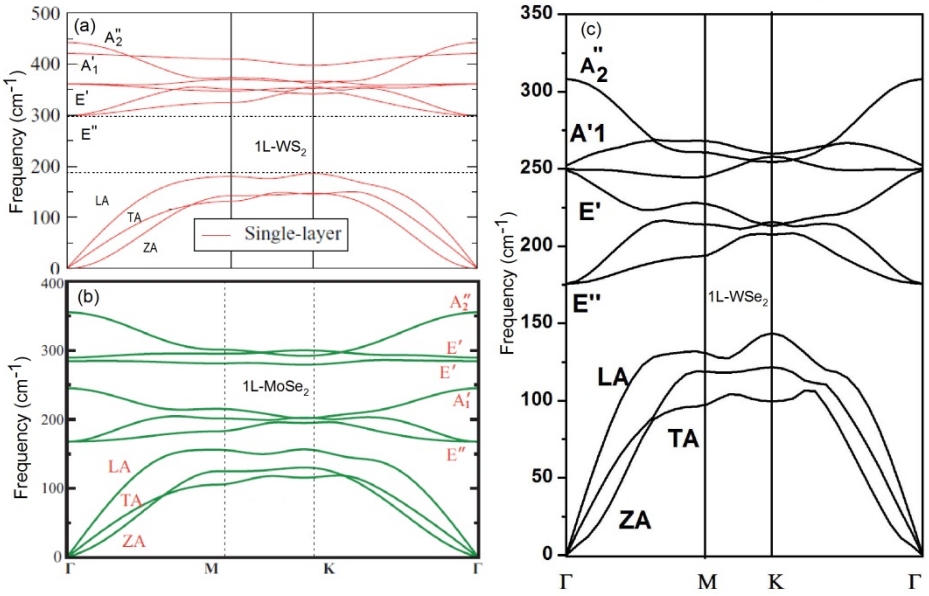

Fig.S1 Phonon dispersion of (a) 1L-WS_2, (b) 1L-$MoSe_2$ and (c) 1L-WSe_2. Reproduced with permission from ref.1. Copyright 2011, American Physical Society. Reproduced with permission from ref.2. Copyright 2013, American Physical Society. Reproduced with permission from ref.3. Copyright 2014, Nature Publishing Group.

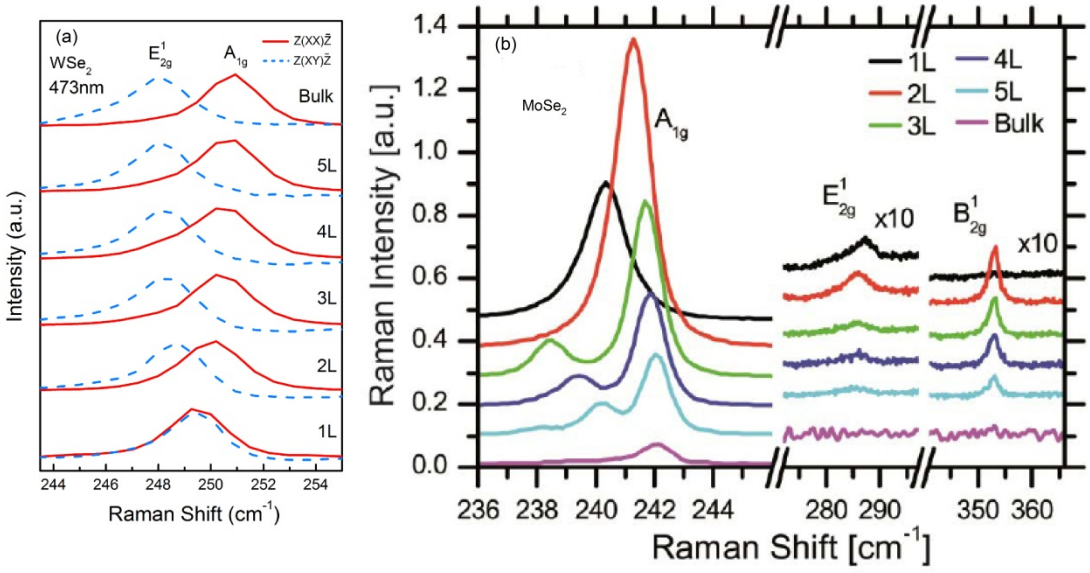

Fig.S2 (a) Polarized Raman spectra of 1-5L and bulk WSe_2 excited by 457nm. Here, E^1_{2g} mode increases in frequency while A_{1g} mode decreases when reduced from bulk to monolayer. Two modes become almost degenerate in 1L-WSe_2, which is identical to the calculated phonon dispersion in Fig.S1. Reproduced with permission from ref.4. Copyright 2013, Royal Society of Chemistry. (b) Raman spectra of 1-5L and bulk $MoSe_2$. Decreasing in frequency of A_{1g} is obvious when thinned down to monolayer, while E^1_{2g} is much weak and its increasing is clearly revealed in 1-3L. Reproduced with permission from ref.5. Copyright 2013, The Optical Society.

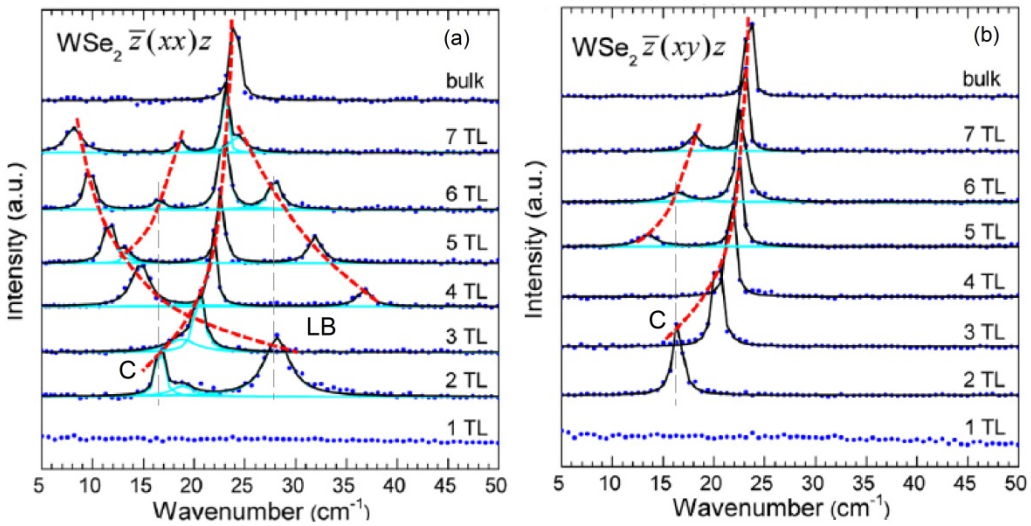

Fig.S3 Polarized ULF Raman spectra of 1-7L and bulk WSe_2 under (a)$\bar{Z}(XX)Z$ and (b)$\bar{Z}(XY)Z$ configurations. Red dashed lines are from the original paper (ref. [6]). Two gray dashed lines denote the C and LB modes from 2L. According to Fig. 6 in main text, C and LB modes from 2L stay almost unchanged with increasing layer thickness. C and LB modes with similar frequency are expected in 2nL-WSe_2 (n=1, 2, 3…). The frequency branches can be reproduced based on Fig. 6. Reproduced with permission from ref.6. Copyright 2013, American Chemical Society.

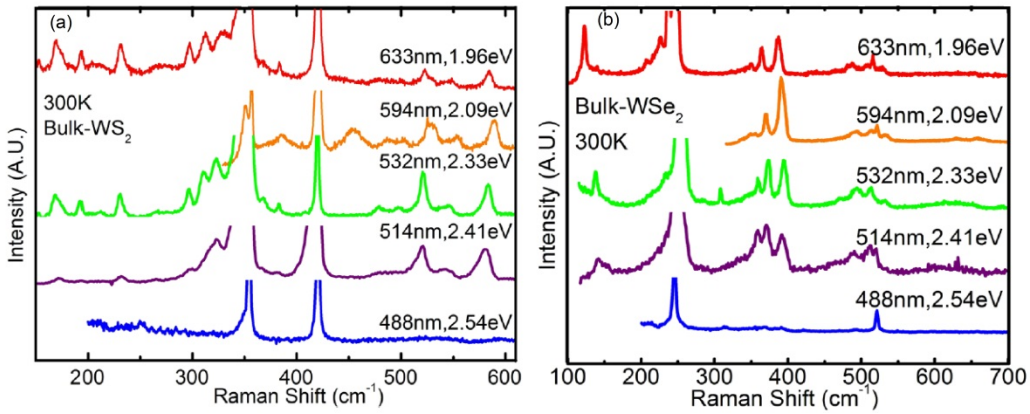

Fig.S4 Raman spectra of bulk (a) 2H-WS_2 and (b) 2H-WSe_2 at five excitation wavelengths. Reproduced with permission from ref.7. Copyright 2014, AIP Publishing LLC.

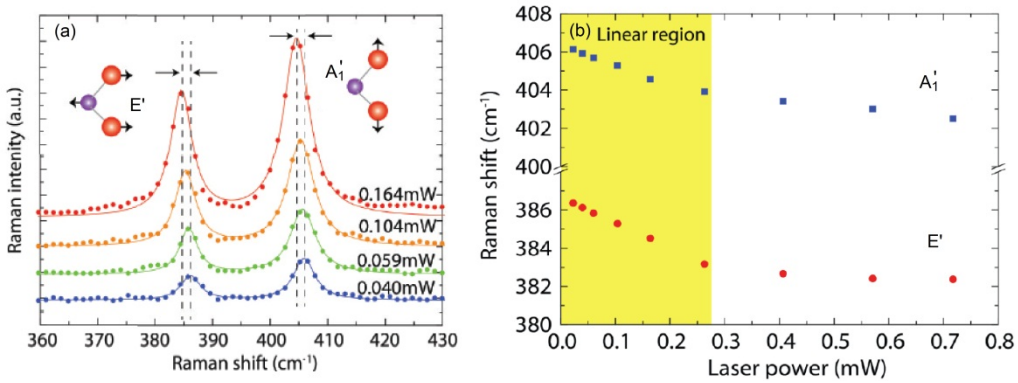

Fig.S5 (a) Four example Raman spectra of suspended, monolayer MoS_2 at increasing excitation laser power at Room Temperature in air environment. (b) The Raman peak frequencies of E' and A'_1 modes for laser power up to 0.72 mW for the suspended monolayer MoS_2 flake. Nonlinearity in the Raman peak position occurs above approximately 0.3 mW, beyond the linear region shown in yellow. Reproduced with permission from ref.8. Copyright 2014, American Chemical Society

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