Raman scattering in single layer MoS_2: Phonon bandwidths, zone edge phonons and 2D effects.

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The discovery of graphene has opened up a wide domain of investigation related to the properties and characteristics of two dimensional materials. Raman scattering has been particularly useful in the case of graphene for identifying the number of layers as well as for studying effects such as electron-phonon coupling, doping, and the formation and concentration of defects.

Molybdenum disulfide is a dichalcogenide that can be prepared in single or few layer configurations by the anodic bonding method [1,2], (Figure1). These samples are stable and insensitive to chemical changes so that fundamental vibrational properties can be investigated using Raman scattering.

In this work we measure phonons in single, few layer and bulk MoS_2 using single and multiple phonon Raman scattering (Figure2). We confirm that the variation of E_{2g} and A_{1g} Raman shifts seen by Lee et al. [3] is a reliable measure of the number of layers in this material.

We compare experiments with ab-initio phonon calculations and address some open questions concerning two phonon Raman scattering in MoS_2 and subtle differences between the bulk and monolayer phonon spectra.

[1]Shukla, A.; Kumar, R.; Mazher, J.; Balan, A. Graphene Made Easy: High Quality, Large-Area Samples. Solid State Commun. 2009, 149, 718– 721

[2]Balan, A.; Kumar, R.; Boukhicha, M.; Beyssac, O.; Bouillard,J.-C.; Taverna, D.; Sacks, W.; Marangolo, M.; Lacaze, E.;Gohler, R.; et al . Anodic Bonded Graphene. J. Phys. D-Appl.Phys. 2010, 43, 374013

[3]C. Lee ; Hugen Yan ; Louis E.Brus; Tony F.Heinz ; James Hone ; Sunmin Ryu , “Anomalous Lattice Vibrations of Single-and Few-Layer MoS2,” ACS nano 4, no. 5 (2010): 2695–2700.

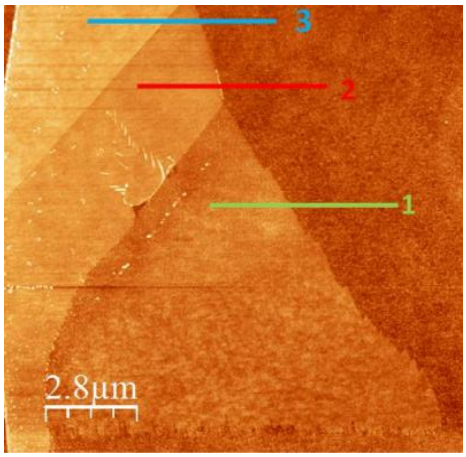

Figure1: AFM image of 1, 2 and 3 layers of MoS2.

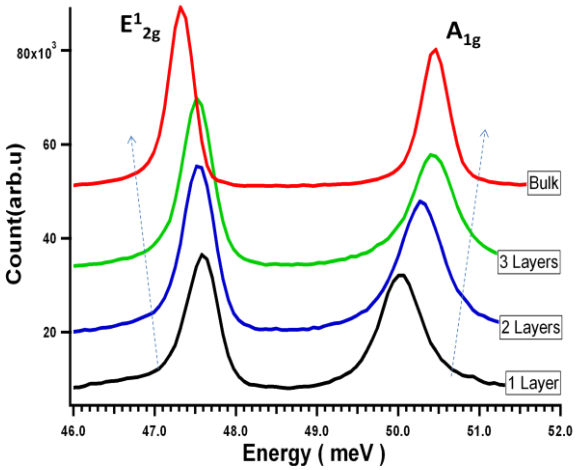

Figure2: E_{2g} and A_{1g} lines evolution as a function of number of layers.