A Study of the Metal/2D Semiconductor Contacts

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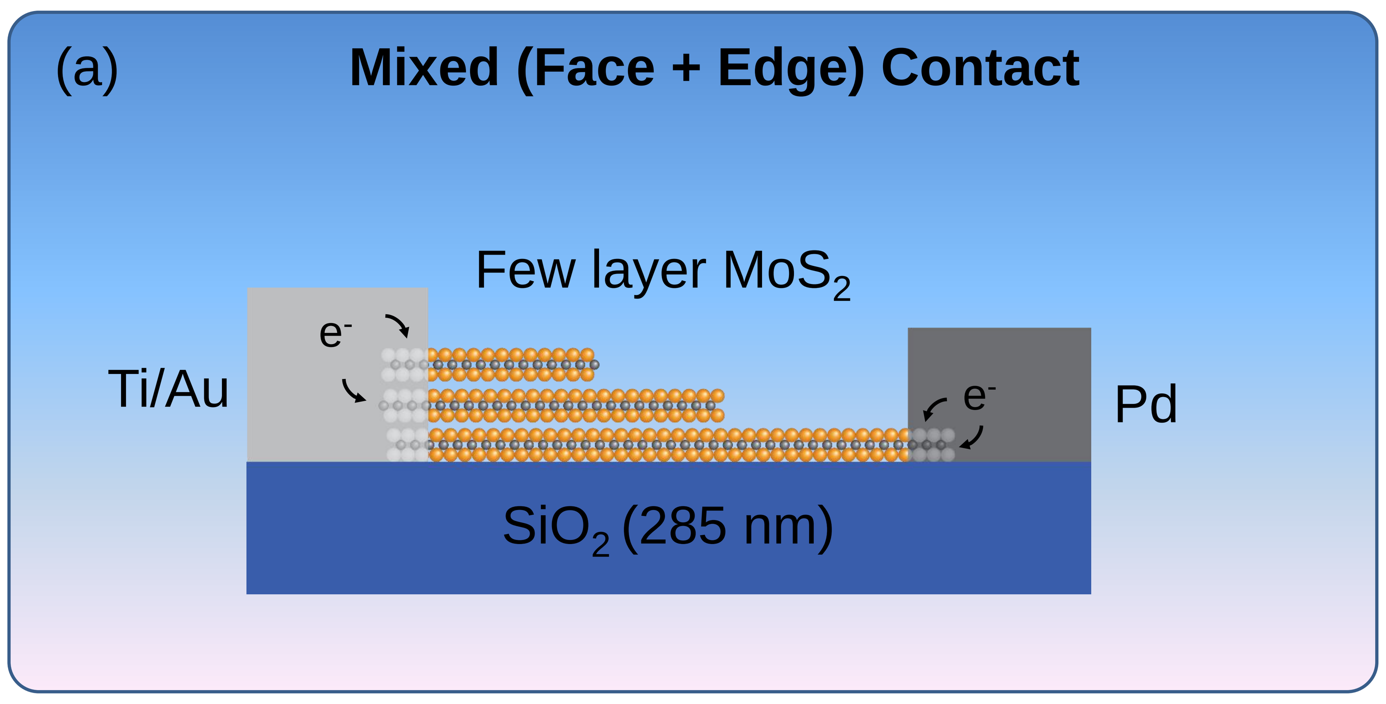
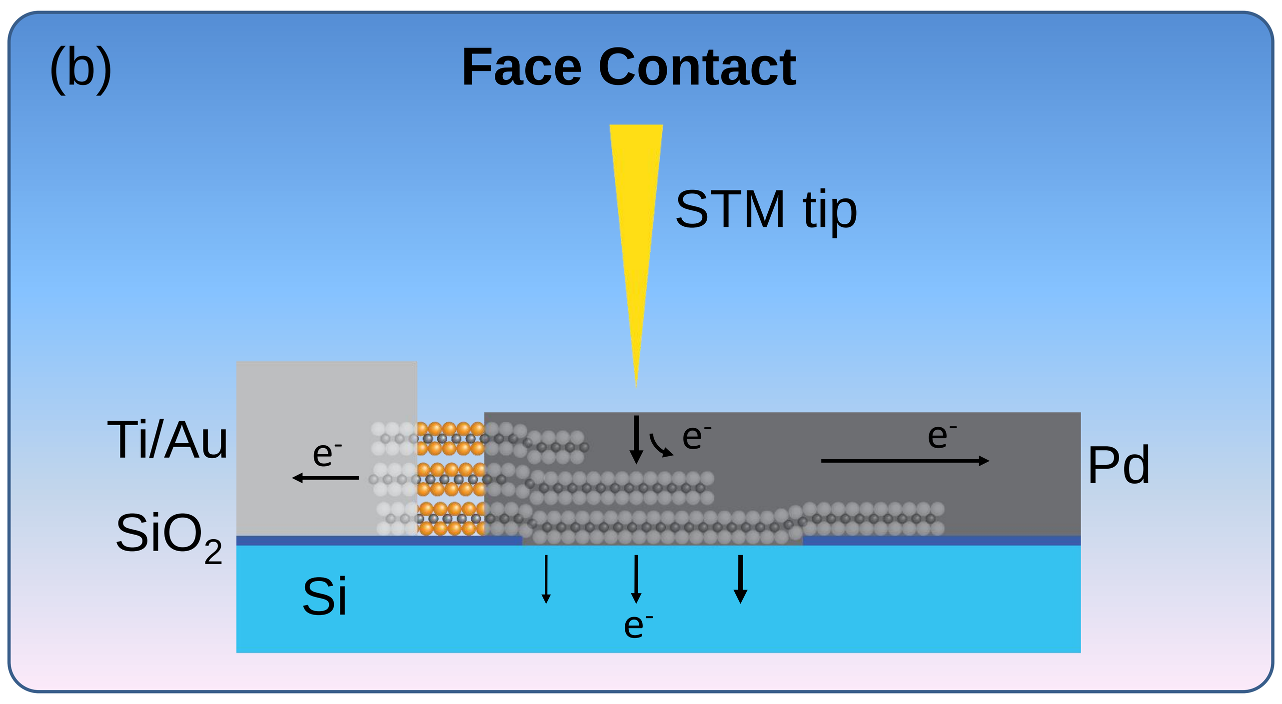
Introduction

Two dimensional (2D) semiconductors based on transition metal dichalcogenides (TMDCs) such as MoS_2, $MoSe_2$, WS_2 and WSe_2 are promising materials for use in next generation electronics due to the presence of a bandgap in these materials and their tuneable electronic and optical properties. One of the major challenges in current research is to understand the nature of the metal/2D semiconductor contacts as the charge injection *into* and *through* the little understood interfaces are limiting the performance of these devices.[1,2] In this poster, we present our strategy for investigating the Pd/MoS_2 Schottky interface using ballistic electron emission microscopy (BEEM) and explain its merit as a model system for understanding the metal/2D semiconductor interface.

Experimental Design

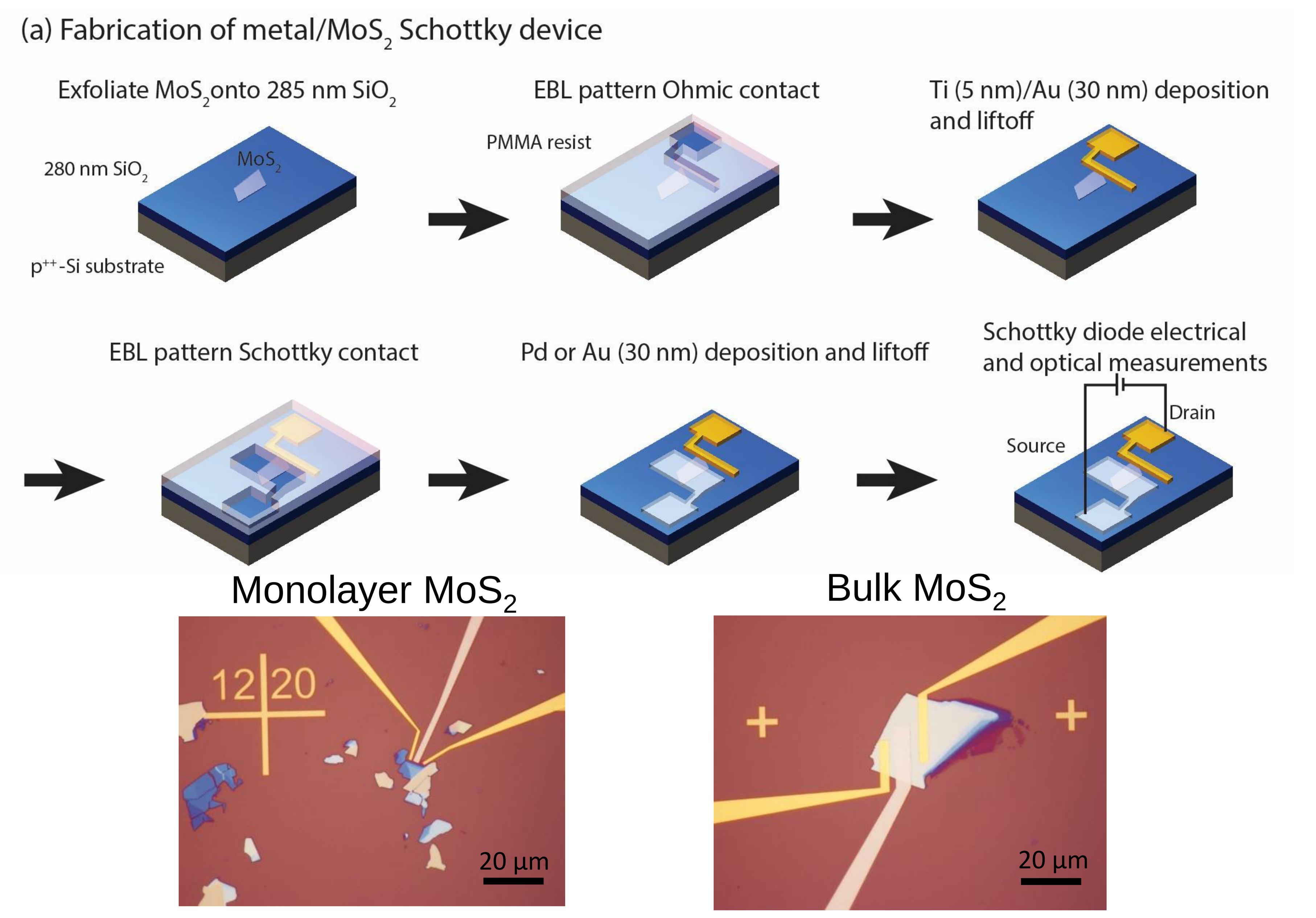
A fundamental problem in the understanding of the metal/2D semiconductor interface arises due to the anisotropy of the in-plane and out-of-plane electrical conductivity of the 2D semiconductor. The in-plane conductivity is typically two orders of magnitude higher than the out-of-plane conduction which may severely affect the charge transport into the 2D semiconductor. We propose two devices to study the mixed and face contacts of the metal/MoS_2 contact. (a) the Pd/MoS_2 Schottky junction and (b) the Pd/MoS_2/Si heterojunction.

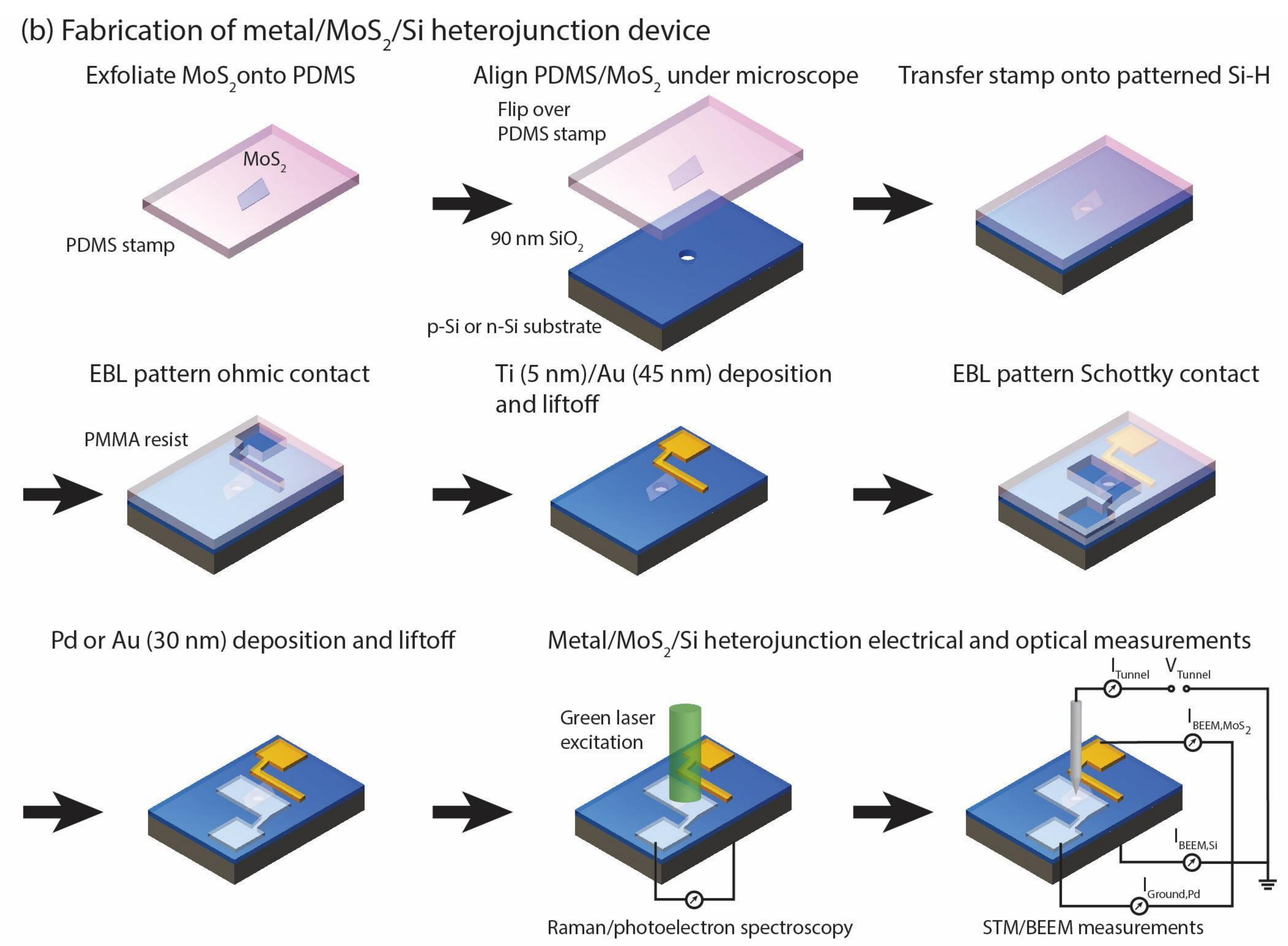




To study the mixed contact, we will use macroscopic electrical measurements such as temperature dependent current-voltage measurements (*I-V-T*). To study the face contact, we will use ballistic electrons from the STM tip to probe the buried metal/MoS_2 contact in a 4-probe ultra-high vacuum scanning tunneling microscope (UHV-STM) system set up in ballistic electron emission microscopy (BEEM) configuration.[3]

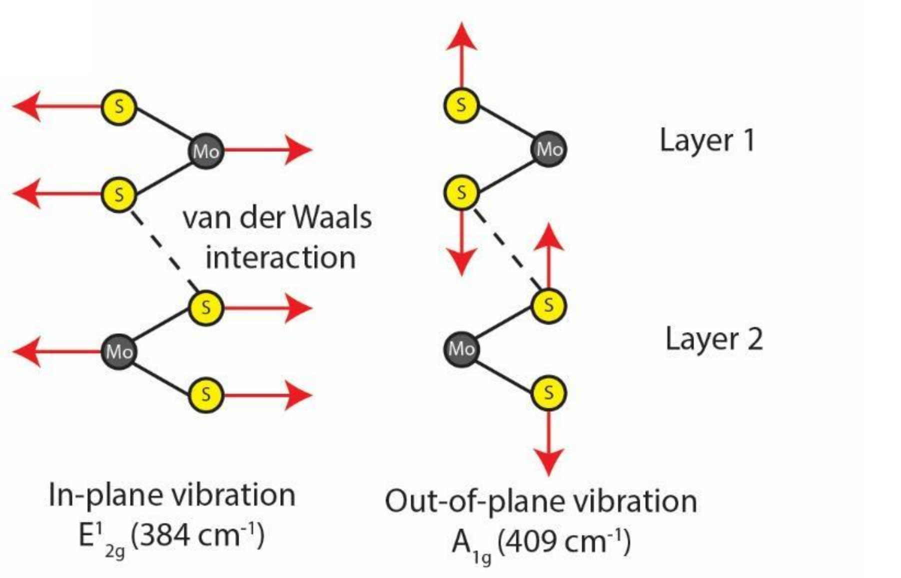
Device Fabrication: Metal/2D Semiconductor Schottky Diode

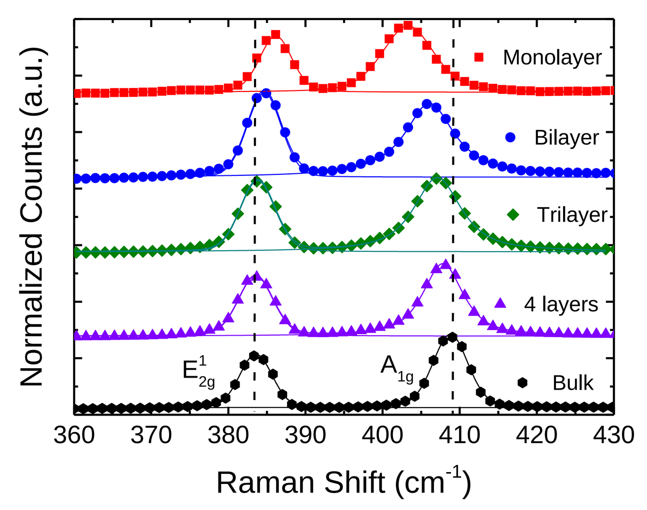


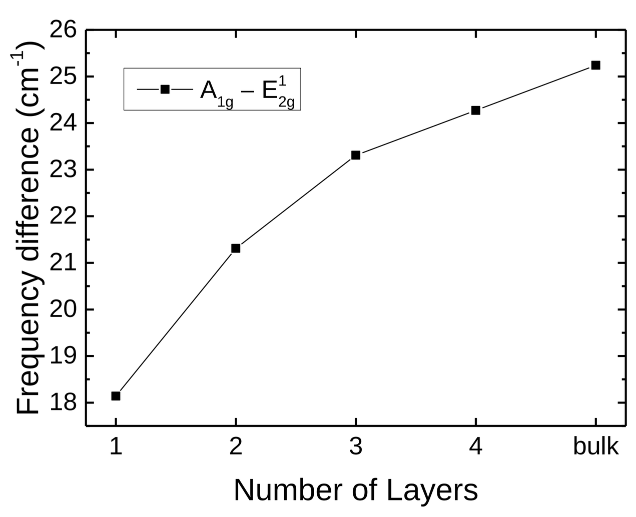


Starting with exfoliated MoS_2, we can pattern and deposit the metal contacts using electron beam lithography (EBL) and liftoff onto small structures.

Raman Spectroscopy







E^1_{2g} mode hardens due to increasing long range electrostatic forces as the screening effect decreases down to the monolayer. A_{1g} mode softens due to decreasing van der Waals forces as MoS_2 thins down to the monolayer.

Conclusion and Outlook

We have presented our strategy to study the metal/2D semiconductor edge or face contacts by fabricating 2 types of metal/2D semiconductor devices and measuring them using conventional *I-V-T* measurements and ballistic electron emission microscopy. We expect to see a layer dependence charge injection efficiency into MoS_2 using the face contact. Fabrication of the metal/2D-semiconductor Schottky and heterojunction device are currently in progress.

Acknowledgements

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