Probing 2D material 1T-TaS_2 at the atomic scale

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Introduction

Scanning Transmission Electron Microscopy (STEM) allows us to image materials at the atomic scale to study their structure and properties. Our goal is to create a platform for which we can tune materials by applying electrical bias to manipulate their properties. In this study we focus on the 2D material 1T-TaS_2, which was exfoliated to create a thin sample which was then imaged using scanning transmission electron microscopy and can be tuned *in situ* with an electrical bias to drive a charge density wave phase transition.

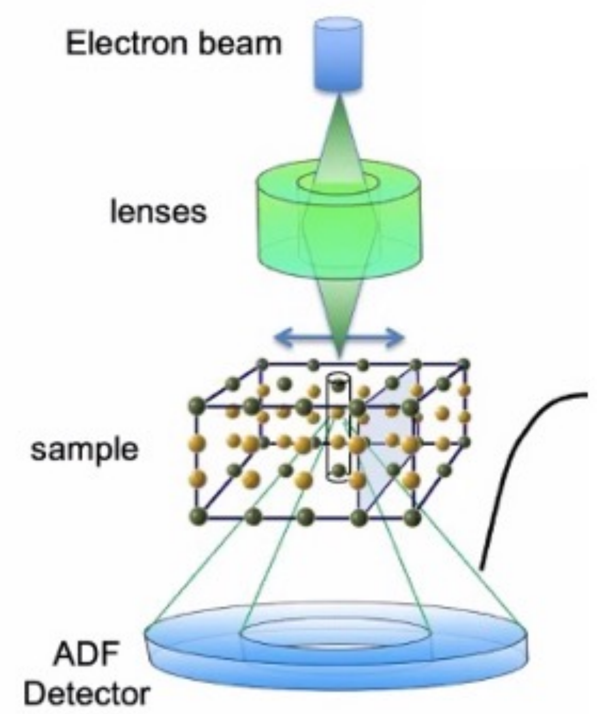

Figure 1. Scanning Transmission Electron Microscopy

Experimental Methods

To be able to image and study 1T-TaS_2 a thin sample must be prepared. To get a thin flake, the material is exfoliated using scotch tape. The samples are transferred from the scotch tape to the gel polymer PDMS which is inspected under an optical microscope shown in figure 2. A thin flake is then selected and stamped down from the PDMS to a Si_3N_4 TEM grid. The grid is then inserted into the STEM microscope to be further imaged.

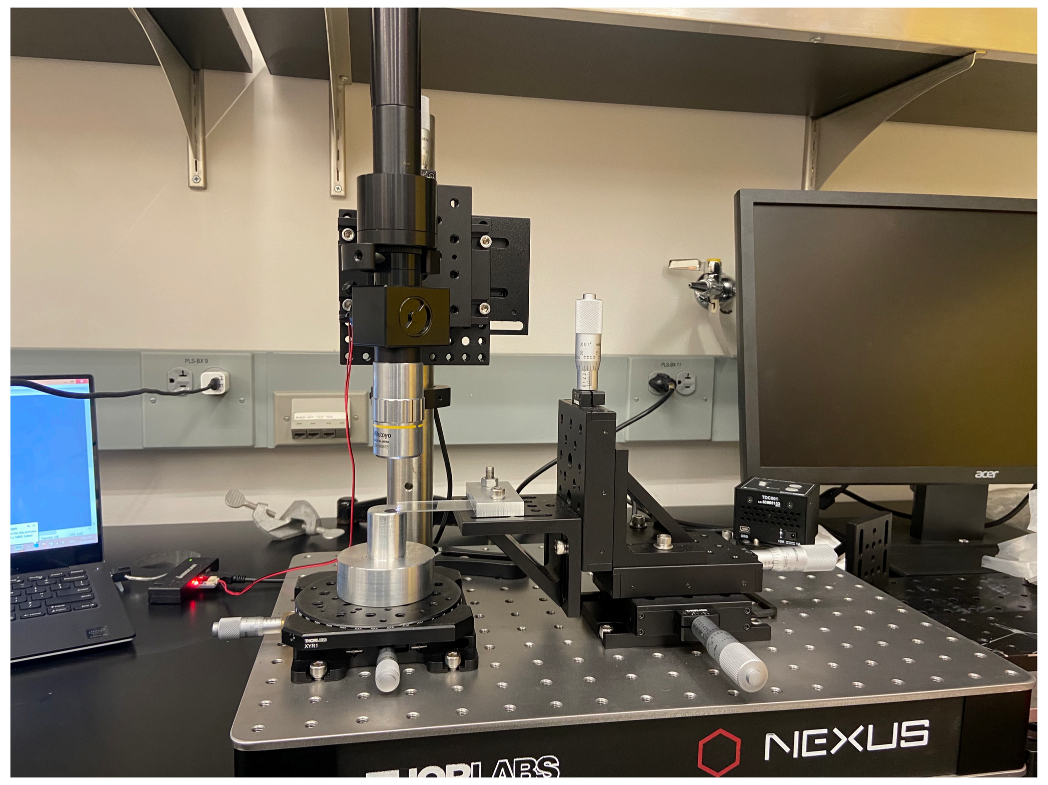

Figure 2. Optical microscope used to look at exfoliated 1T-TaS_2 flakes.

Results

- A thin flake of 1T-TaS_2 was stamped down over a hole on the Si_3N_4 TEM grid to allow electrons from the electron beam to pass through the sample in the STEM microscope.
- The sample was imaged at atomic resolution in figure 3.
- Images and diffraction pattern taken at room temperature are in the nearly commensurate phase.
- Using position averaged convergent beam electron diffraction (PACBED) pattern to roughly compare thickness of the sample.
- The sample is roughly about 4.72 nm or 5.32 nm thick

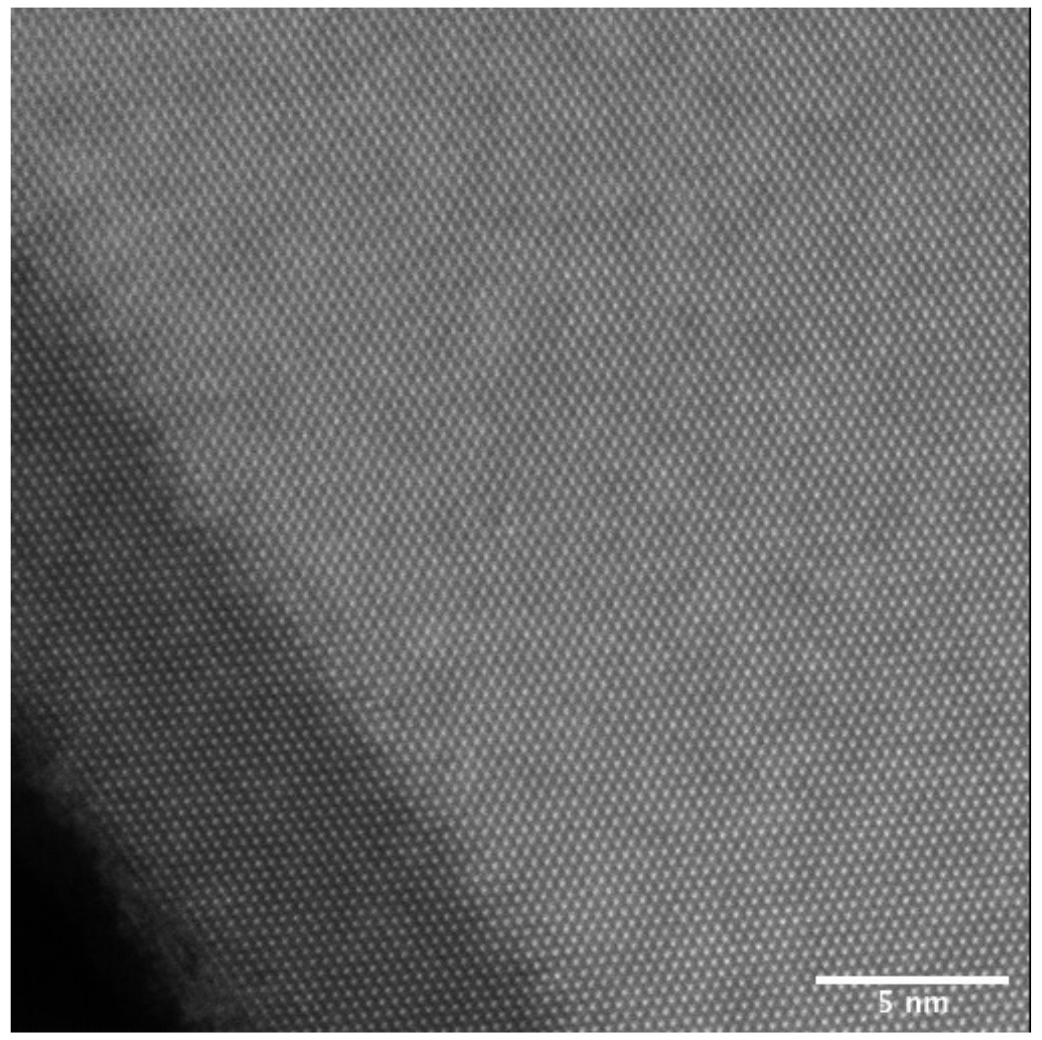

Figure 3: Atomic resolution STEM image of 1T-TaS_2 at room temperature.

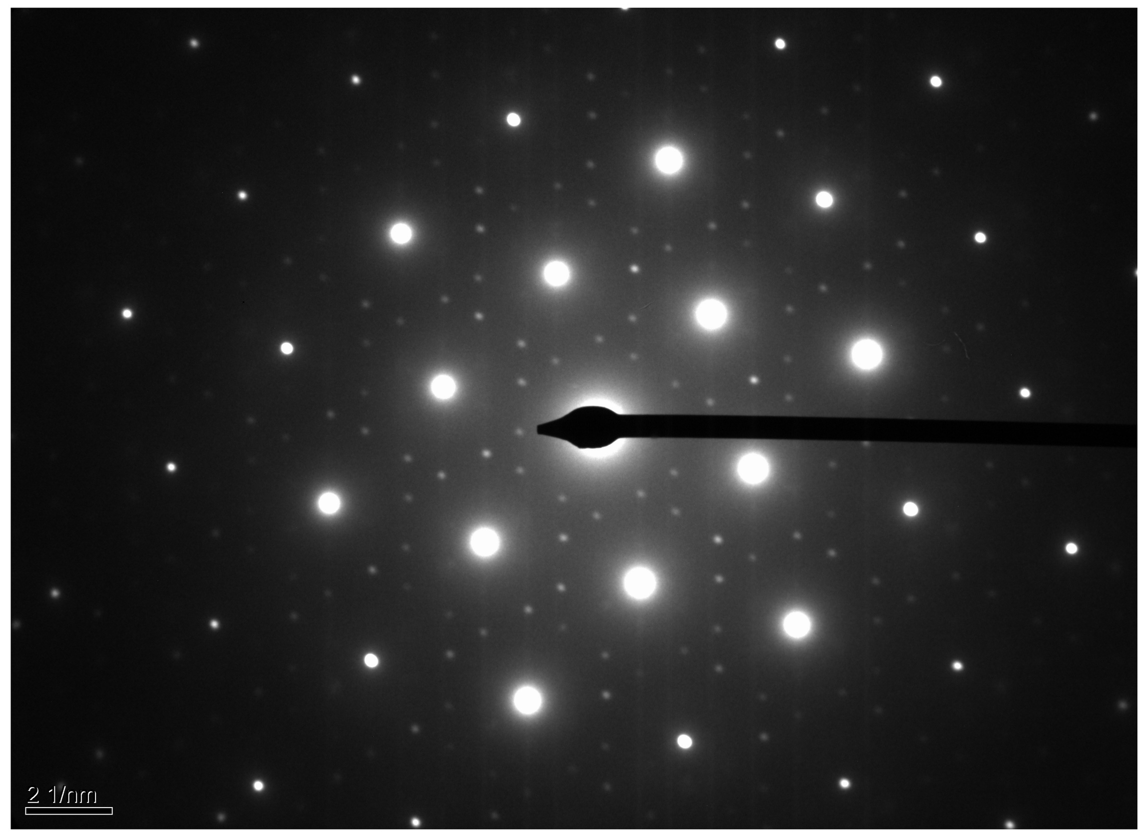

Figure 4: Diffraction pattern of 1T-TaS_2 at room temperature

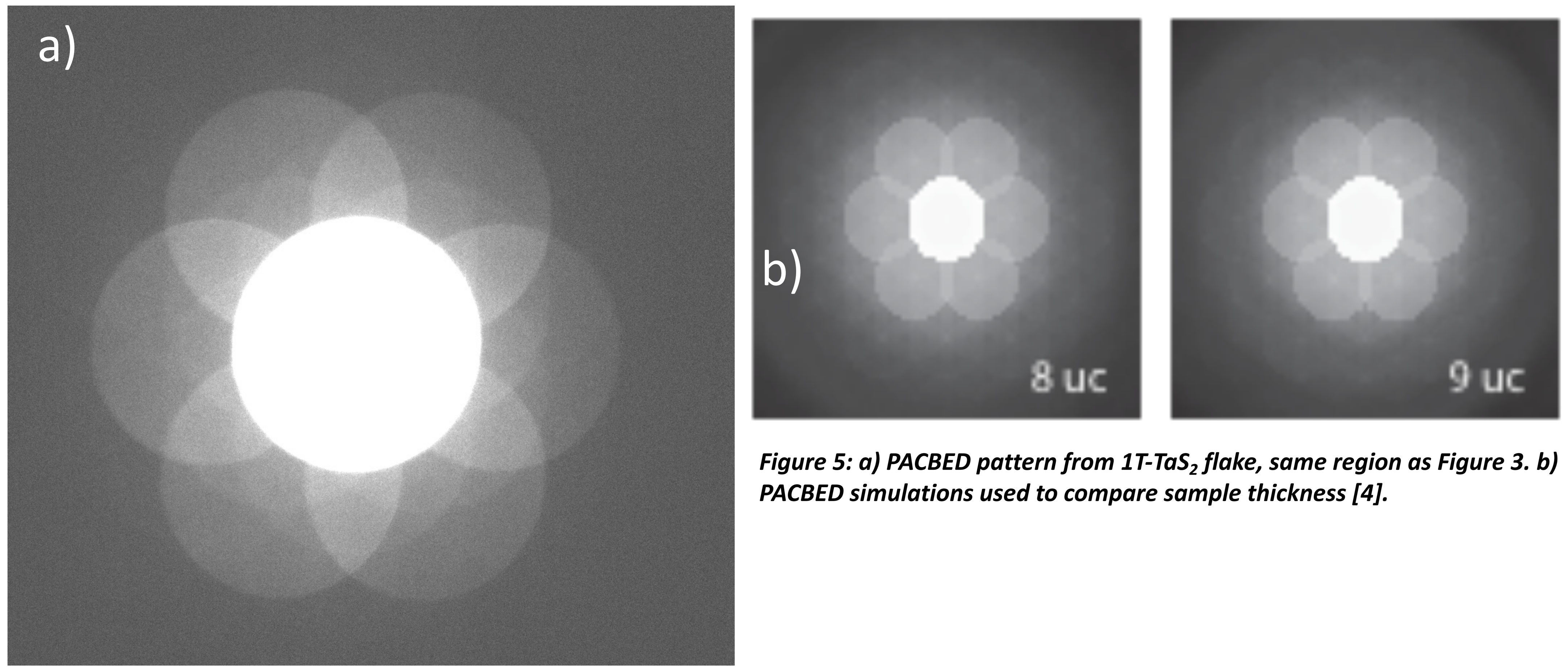

Figure 5: a) PACBED pattern from 1T-TaS_2 flake, same region as Figure 3. b) PACBED simulations used to compare sample thickness [4].

Conclusions and Future Work

1T-TaS_2 was imaged on a Si_3N_4 TEM grid but has not yet been successfully stamped onto a four contact biasing chip. Once a thin flake is able to be stamped onto a chip, it can then be inserted into the STEM microscope with an applied bias to physically see how 1T-TaS_2 properties change under these conditions.

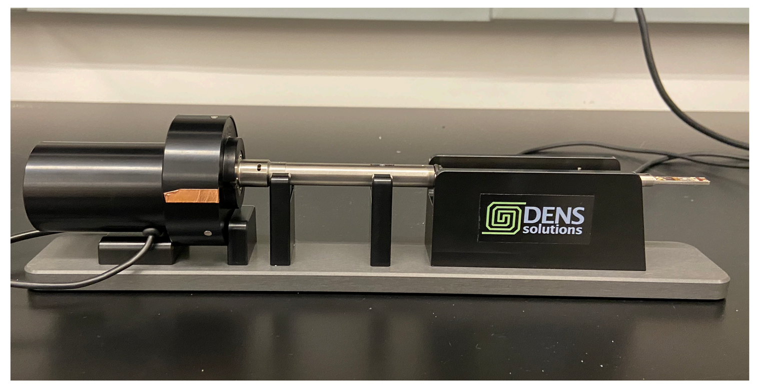

Figure 6: Biasing holder that is inserted into STEM.

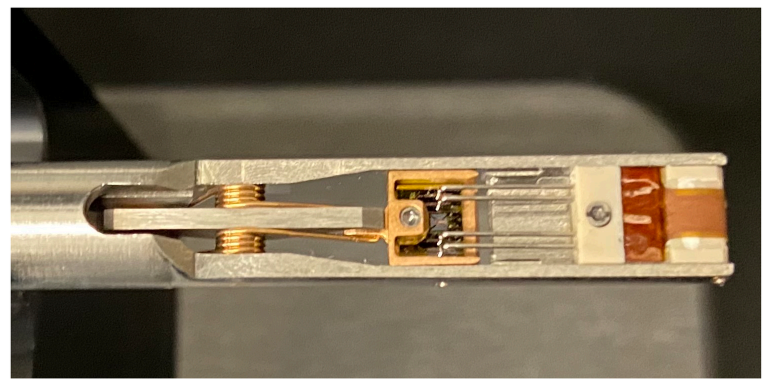

Figure 7. Section of the biasing holder where the biasing chip is placed. Four contact biasing.

References

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[4] Hovden, R., Liu, P., . . . (2018). Thickness and Stacking Sequence Determination of Exfoliated Dichalcogenides (1T-TaS2, 2H-MoS2) Using Scanning Transmission Electron Microscopy. *Microscopy and Microanalysis, 24*(4), 387-395.

Acknowledgements

- Thanks to my mentor Yue Yu.
- Thank you to my PI Lena Kourkoutis for help in and outside the lab.
- Thank you to Noah Schnitzer for help in the lab.
- Thank you to PARADIM