## Benchmarking monolayer MoS<sub>2</sub> and WS<sub>2</sub> field-effect transistors

Local User Project - 2021

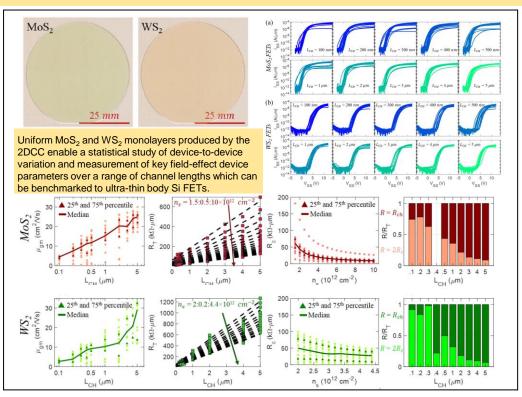
2DCC MIP at Penn State,

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**Project Summary:** To assess the potential of transition metal dichalcogenides (TMDs) for future circuits, it is important to study the variation in key device parameters across a large number of devices. Here we benchmark device-to-device variation in fieldeffect transistors (FETs) based on wafer-scale monolayer MoS<sub>2</sub> and WS<sub>2</sub> Our study involves 230 MoS<sub>2</sub> FETs and 160 WS<sub>2</sub> FETs with channel lengths ranging from 5 µm down to 100 nm. We use statistical measures to evaluate key FET performance indicators for benchmarking these TMD monolayers against existing literature as well as ultra-thin body Si FETs. Our results show consistent performance of the 2D FETs across 1×1 cm<sup>2</sup> chips owing to high quality uniform layers and clean transfer onto device substrates. We demonstrate record high carrier mobility of 33 cm<sup>2</sup>V<sup>-1</sup>s<sup>-1</sup> in WS<sub>2</sub> FETs, which is a 1.5X improvement compared to the best literature report. Our results confirm the technological viability of 2D FETs in future integrated circuits. Published in Nature Communications 2021, 12, 1-12.

**2DCC Role:** The wafer-scale  $MoS_2$  and  $WS_2$  monolayer samples used for this study were grown by metalorganic chemical vapor deposition (MOCVD) in the 2DCC facility. The device results provide a benchmark for academic and industry users who are working with similar 2DCC material.





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