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Electron transport and device physics in monolayer transition-metal dichalcogenides

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Two-dimensional transition-metal dichalcogenides (TMDs) represent a promising class of materials for electronic and photonic devices, benefiting from their sizable bandgap of 1-2eV and ultrathin body. However, one of the major issues is that the experimental mobility is much lower than the theoretical phonon limit. It is speculated that the mobility is degraded by many extrinsic factors. In this talk I will present our systematic investigations on the electron transport and field-effect transistors of monolayer TMDs (including MoS_2 and WS_2). We find that the major extrinsic mobility limiting factors are charged impurities, traps and point defects. We develop a facile low-temperature thiol chemistry to repair the sulfur vacancies and improve the interface quality, resulting in significant reduction of the charged impurities and traps. In combination with high-k dielectrics that further screens the charged impurities, we are able to achieve record-high room-temperature mobilities of ~150cm^2/Vs and 83cm^2/Vs for monolayer MoS_2 and WS_2, repectively. We further develop a theoretical model to quantitatively correlate these extrinsic scattering sources to measured electrical data. Our study shows that interface engineering is critical for high-performance transistors based on 2D semiconductors.

References

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[1]The talk will be given by my student Zhihao Yu