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Challenges for 2D material Integration in Nanoelectronic Devices

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The last decade has seen fevered interest in 2D materials for nanoelectronics. These materials, which include graphene, hexagonal boron nitride, and the plethora of transition metal dichalcogenide (TMD) combinations, have electronic structures exhibiting metallic, semiconducting, and insulating properties. This promises devices with scalability to the atomic limit combined with defect free interfaces. Realizing this promise has not proved trivial. Defects in the naturally occurring material can dominate their properties, and even synthesized materials can suffer from high impurity concentration. Process residues such as photo-resists can impact device performance. Metal depositions can result in the formation of unexpected interface compounds that can dominate the contact behavior. We study both the synthesis and integration of 2D materials for nano- and optoelectronic applications. Using an in-vacuo MBE-ARPES cluster tool, we grow TMDs from elemental sources using van der Waals epitaxy. The layer-by-layer nature of these growths can be verified in-situ using reflection high-energy electron diffraction. The composition and electronic structure of these materials can be investigated by in-vacuo XPS and ARPES. In addition to studying the synthesis of these materials, we also investigate how these materials interface with metals that are commonly used as contacts in electronic devices. Recently it has been shown that the process conditions during the electron beam deposition of metals can control interface reactions. In particular, the reactor base pressure and deposition rate can be used to tune the interface chemistry. We will present a summary of our work on the synthesis of TMDs and the interfaces formed between these materials and typical device contact metals.