Towards Atomically Precise Material Fabrication: Defect Engineering of Layered Materials Using Focused Ion Beams

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The scalability of electronic and information technology devices depends on the ability to tune layered materials. With the recent development of CVD-growth processes for high quality 2-dimensional materials, large scale fabrication of these materials is become routine. However, critical is the structuring and functional tuning of these materials, as currently being done for semiconductors. Here, I will discuss the use of focused helium ion beams in tailoring the functionality of 2D materials including graphene, dichalcogenides and copper indium thiophosphate (CIPS) with nanometer precision. Using a helium ion beam under high dosing allows for milling and structuring of devices with nanometer precision and prevents ion implantation and resist contamination effects. For lower helium ion doses we are able to tune the mobility as ascertained by local transport measurements. The nature of the associated properties of this material were explored using a combination of aberration-corrected scanning transmission electron microscopy (STEM), scanning probe microscopy (SPM) and optical spectroscopy and mass spectrometry techniques that provided insight into local mechanical, electromechanical, chemical and atomic structure properties of these devices and elucidate the effect of ion beam dose on device performance. Future perspective and scalability of this approach to device fabrication will also be discussed.