Atomically-Thin Materials and Heterostructures

The last decade has seen an exponential growth in the science and technology of two-dimensional materials. Beyond graphene, there is a huge variety of layered materials that range in properties from insulating to superconducting. Furthermore, heterogeneous stacking of 2D materials also allows for additional “dimensionality” for band structure engineering. In this talk, I will discuss recent breakthroughs in two-dimensional atomic layer synthesis and properties, including novel 2D heterostructures and realization of unique 2D allotropes of 3D materials (e.g. 2D-GaN and Ga2O3). Our recent works demonstrate that the properties and doping of 2D materials, especially synthetic 2D materials, are extremely sensitive to the substrate choice. I will discuss substrate impact on 2D layer growth and properties, doping of 2D materials, selective area synthesis of 2D materials, and 2D nitrides beyond hBN. Our work and the work of our collaborators has lead to a better understanding of how substrate not only impacts 2D crystal quality, but also doping efficiency in 2D materials, and stabalization of nitrides at their quantum limit.

References
1. Properties of synthetic epitaxial graphene/molybdenum disulfide lateral heterostructures, Carbon (125), Pages 551-556
2. Deconvoluting the Photonic and Electronic Response of 2D Materials: The Case of MoS2, Scientific Reports 7, Article number: 16938
3. Two-dimensional gallium nitride realized via graphene encapsulation; Nature Materials 15, (1166–1171)
4. Selective-area growth and controlled substrate coupling of transition metal dichalcogenides; 2D Materials; 4; 2: 25083
5. Growing Vertical in the Flatland; ACS Nano, 2016, 10 (1), pp 42-45

Figures

Fig.1: Examples of (a) wafer-scale WSe2, (b,c) 2D heterostructures, and (d) 2D-Gallium Nitride.