Novel sulfide heterostructures from designed precursors

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Composite 2D material systems present not only unique structural and electrical phenomenon but can be intentionally designed to elicit properties desirable for a specific application. Existing reports of chalcogenide heterostructures have shown the ways in which varying thicknesses of constituent layers from monolayer to bulk-like affects the resistivity, [1] transport properties, [2] and overarching band structure [3] of such systems. To date, systems in this vein are limited to selenides and tellurides. Extension to sulfide systems is important to harness properties of emerging 2D materials such as MoS_2 and WS_2.

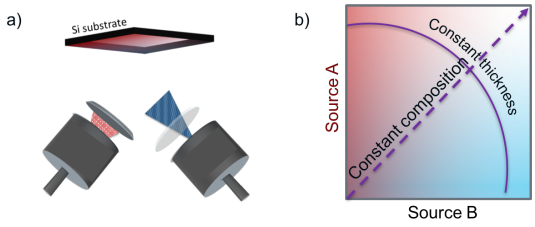

Figure 1: *a) Chamber geometry for samples synthesized combinatorially. b) Description of resulting composition and thickness gradients on a sample surface.*

In this work we demonstrate the synthesis of multilayer sulfide heterostructures crystallized from amorphous precursors via sputter deposition. We utilize a combinatorial approach to depositions in order to reduce time and specificity needed in calibrating the time needed to deposit constituent components of such structures. A schematic of this setup can be seen in Fig. 1. Here we will focus on spatially resolved structural characterization of these combinatorial samples with respect to changes in long range ordering indicative of improved crystallinity. Additionally, we investigate the role of off-stoichiometry in as-deposited precursors on the structure and quality of our crystalline end product. Challenges inherent in sulfur-based depositions are also addressed.

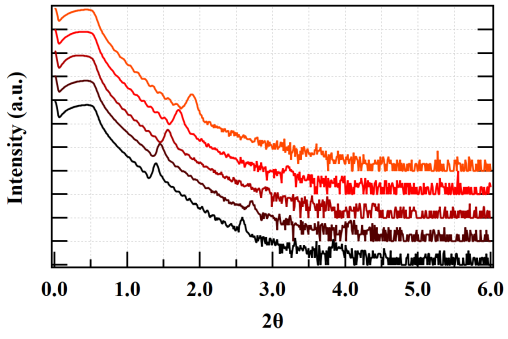

Figure 2: *X-ray reflectivity patterns for combinatorial amorphous precursor indicative of layer ordering.*

[1] M. Alemayehu, *et al. Chem. Mat.* **2015**, 27, 867-875.
[2] S. Bauers, *et al. J. Alloys and Compounds.* **2015,** 645, 118-124.
[3] D. M. Hamann *et al. Semicond. Sci. Technol.* **2017**, 32, 093004.