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Molecular Beam Epitaxy of Layered Material Superlattices and Heterostructures SURESH VISHWANATH, Department of Electrical Engineering, Univ of Notre Dame, XINYU LIU, Department of Physics, Univ of Notre Dame, SERGEI ROUVIMOV, Notre Dame Integrated Imaging Facility, Univ of Notre Dame, JACEK K. FURDYNA, Department of Physics, Univ of Notre Dame, DEBDEEP JENA, HUILI GRACE XING, Department of Electrical Engineering, Univ of Notre Dame — Stacking of various layered materials is being pursued widely to realize various devices and observe novel physics. Mostly, these have been limited to exfoliation and stacking either manually or in solution, where control on rotational alignment or order of stacking is lost. We have demonstrated molecular beam epitaxy (MBE) growth of $Bi_2Se_3/MoSe_2$ superlattice and $Bi_2Se_3/MoSe_2/SnSe_2$ heterostructure on sapphire. We have achieved a better control on the order of stacking and number of layers as compared to the solution technique. We have characterized these structures using RHEED, Raman spectroscopy, XPS, AFM, X-ray reflectometry, cross-section (cs) and in-plane (ip) TEM. The rotational alignment is dictated by thermodynamics and is understood using ip-TEM diffraction patterns. Layered growth and long range order is evident from the streaky RHEED pattern. Abrupt change in RHEED pattern, clear demarcation of boundary between layers seen using cs-TEM and observation of Raman peaks corresponding to all the layers suggest van-der-waals epitaxy. In our knowledge this is a first demonstration of as grown superlattices and heterostuctures involving transition metal dichalcogenides and is an important step towards the goal of stacking of 2D crystals like lego blocks.

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