Synthesis of 2D Materials by Molecular Beam Epitaxy

R. Trice, M. Yu, M. Hilse, S. Law

Abstract:

2D materials have exploded in popularity due to a large range of novel properties and applications, for quantum computing to optoelectronic systems. Of the many ways to synthesis these materials, molecular beam epitaxy (MBE) offers distinct advantages through creating high-quality films at low temperatures with precise control of growth parameters. Two interesting and attractive van der Waals (vdW) materials grown by MBE are Bi_2Se_3 and GaSe. Bi_2Se_3 is an 3D topological insulator (TI) that is attractive due to its ease of synthesis, relatively large band gap, thermoelectric properties, and TI properties. GaSe is another vdW material of interest due to its intriguing bandgap behavior and is an ideal choice for quantum photonic technology. Quantum dots and emitters of these 2D materials are particularly promising.

In this study, an investigation into the growth of Bi_2Se_3 and GaSe on different substrates, with the eventual goal of creating quantum dots and emitters, was performed. Unlike traditional epitaxy, vdW materials may grow on substrates with large differences in lattice constant/structure as the weak interlayer bonds make them less affected by substrate. However, preparation and choice of the substrate can still make a large difference in the quality of the films. Investigations of Bi_2Se_3 growth on c-plane sapphire substrates and the influence of substrate preparation were studied. Similarly, the growth of GaSe films on sapphire and GaAs (111)B were looked at. From these improvements in substrate preparation and growth of both Bi_2Se_3 and GaSe films we hope to eventually grow on patterned substrates to obtain wafer-scale films with site-controlled localized quantum dots and emitters.