Growth & Characterization of III-V Semiconductors

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Abstract: III-V semiconductors are a mature class of materials with commercial applications in electronics, optoelectronics, spintronics, and photovoltaics. Molecular Beam Epitaxy (MBE) is an ultrahigh vacuum technique used to synthesize these materials with high purity and a low number of defects. Ongoing research topics include the synthesis of metamaterials for infrared (IR) sensing applications and the synthesis of novel topological materials. A certain class of metamaterials called hyperbolic metamaterials can help overcome the diffraction limit, by transmitting near field optical signals without decay. A superlattice structure of strained GaSb (dielectric) and Si:InAs (optical metal) can be grown using MBE and fabricated to make rolled up microtubes with radially alternating layers of dielectric and metal. This unique device will have applications in infrared super-resolution microscopy by transmitting rapidly decaying near-field signals in the far field. Topologically non-trivial materials have interesting electronic and optical properties, including large magnetoconductivity and nonlinear optical responses, making these materials useful for electronic and optoelectronic applications. The primary materials of interest are the III-Bi compounds such as AlBi, GaBi, and InBi. These materials have been shown to have non-trivial topological band structures as topological insulators (AlBi) and topological semimetals (GaBi and InBi). We are interested in studying the synthesis-structure-property relationships in these materials that have not been extensively studied previously. Additionally, due to both the topological nature of these materials and the compatibility with other III-V materials, we expect the bismuthides to also be candidates for IR sensing solutions.