Research themes of Quantum Materials Laboratory

Quantum materials represent a vibrant research area intersecting with condensed matter physics and materials science, moving beyond explanations offered by classical or semiclassical and quantum theories. Our group extensively investigates these materials to uncover the intriguing low-dimensional physics, such as phase coherent quantum transport and quantum confinement effects, crucial for advancements in energy-efficient spintronics, optoelectronics, and quantum computing. Through this research, we aim to pave the way for a technologically advanced and comfortable lifestyle.

At the Quantum Materials Laboratory, IIT Guwahati, our research encompasses a wide array of themes and employs various methods to explore the quantum characteristics of condensed matter. A significant challenge in integrating technologically promising materials into real-world devices is the need to miniaturize bulk-grown crystals in a controlled and reproducible manner. While recent exfoliation techniques have struggled to produce films with precise thickness and lateral size, advancements in bottom-up preparation methods have made significant strides. Epitaxial thin films, which are their bulk counterparts, exhibit promising properties.

We specialize in preparing high-quality epitaxial single-crystalline thin films of various quantum materials to delve into the quantum properties of condensed matter. Our efforts aim to push the boundaries of our understanding and assess the potential of these materials in quantum technologies. Utilizing cutting-edge thin film growth tools such as chemical vapor transport and molecular beam epitaxy, we create thin films and nano-dimensional structures like quantum wells, quantum dots, and nanowires to study quantum size effects. We employ complementary characterization techniques to analyze the structural, optical, electrical, electronic, superconducting, and magnetic properties of the epitaxial films. These fundamental characteristics form the basis for leveraging quantum materials in optoelectronics, phase coherent quantum transport, and other relevant quantum technological applications.

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