Crystal Growth and Characterization of Layered Materials

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Understanding the relationship between structure and properties of solids is at the core of materials science. While limited to two dimensions, surface science studies often rely on the cleaving of bulk 3D samples of excellent quality. Furthermore, knowledge of the properties of the bulk is critical for understanding the behaviour at the surface. The easy cleavage of materials with layered crystal structures make them well-suited for surface studies under ultra-high vacuum conditions. The growth of bulk single crystals are performed using different methods, mainly chemical vapour transport, Bridgman-Stockbarger and flux growth. The application of the different methods will be illustrated through selected recent and ongoing studies. The use of high pressure will be discussed as an approach to manipulate and stabilize materials, both into known and novel crystal structures.

The search for materials with specific properties and optimized performance is usually performed by rational and exploratory research, in other words by educated guessing or serendipity. In the recently established Center for Dirac Materials experimental studies at Aarhus University are combined with theoretical prediction and search algorithms. Novel theoretical data mining approaches are used to discover materials with intriguing electronic properties and our focus is the rapid realization of materials for experimental validation using a range of advanced characterization techniques available within the center. To augment conventional solid state chemistry methods for materials synthesis and crystal growth, we have built a comprehensive suite of techniques for high-pressure solid-state chemistry, including a large volume multi-anvil press, capable of generating pressures up to 250,000 bar (25 GPa) and temperatures up to 2000 K and a number of different diamond anvil cells (DACs). These extreme conditions provide exceptional possibilities to manipulate matter into new forms using pressure as the driving force. In many cases, these novel materials can be recovered to ambient conditions as stable or metastable compounds. In the presentation, I will give examples from recent and ongoing research with a focus on perovskites and topological insulators.