Institute for Functional Materials and Devices (I-FMD)

Thrust 1. Materials Synthesis and Growth under Extreme Conditions

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The goal of this thrust is to accelerate the discovery of multifunctional materials with enhanced properties (mechanical, electronic, optical, *etc.*), which can only be synthesized and stabilized under extreme conditions. These materials are critical to addressing numerous societal grand challenges including developing a zero-carbon-footprint transportation and energy infrastructure, and enabling scalable quantum technologies for sustainable computing. The group is focusing on synthesis and growth methods that exploit extremely high pressure, temperature, entropy, confinement, strain engineering, and exposure to strong electromagnetic fields to produce metastable phases of materials that have been previously difficult to create.

The thrust brings together experts in synthesis and growth of materials, materials characterization, and modelling and machine learning; and builds on recent investment by the University by new hires and capital investments. A range of extreme conditions are exploited in specific growth and synthesis methods including; 1. Laser based extreme instantaneous energy in solid-state single crystal growth from glass, atomic layer deposition, and pulsed-laser deposition; 2. Engineering design based extreme pressures/confinement in ammonothermal growth, nanocasting, and spatial CVD; Optimized chemistry based extreme entropy in high energy milling, and selective reduction. These approaches target a range of materials including cubic boron nitride, high-entropy materials, and other novel phases of metal oxides and nitrides.

The group focuses on answering three core scientific challenges. How do we develop synthetic/growth strategies to access highly metastable phases? How do we monitor *in situ* and characterize growth under extreme conditions? How do we predict and model the extreme conditions that allow access to new phases?

These questions are being addressed by establishing a fundamental understanding of the structure/property relationships by developing unique combinations of skillsets in respective synthesis and growth methods, and creating close links between synthesis, modelling, and characterization. Potential applications of these exotic materials include, next generation electronics, photonics, and quantum systems, and ultra-strong or ultra-durable materials. An understanding of conditions that stabilize these new materials will help identify their applications under extreme conditions.