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Growth under the influence of chemistry: the emergence of microstructure and metastable phases far from thermodynamic equilibrium

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One of the challenges in materials growth is that our ability to discover and synthesize new materials has greatly outpaced our ability to predict their microstructure and quality for a given synthesis method. Beyond the intellectual challenge, bridging this microstructure gap can have enormous consequences in areas such as the scale up of nanomaterials. In addition to novel computational methods and characterization techniques, we also need model systems that allow us to study these problems in a controlled way. Atomic layer deposition (ALD) is a materials synthesis technique that relies on sequential self-saturating reactions to synthesize materials with great degree of reproducibility and precision. These properties make it an ideal model system to study the relationship between growth kinetics and microstructure at the nanoscale. In this talk I will focus on the application of ALD as a model system to understand materials growth at low temperatures, and its ability to synthesize novel metastable nanolaminate phases. Our research leverages the unique capabilities at the Advanced Photon Source, including the development of a portable ALD system to carry out in-situ studies. Finally, I will briefly describe the computational challenges in predictive synthesis.