Controlling microstructures in multiphase or composite materials is one of the primary routes for materials design for optimal performance. Phase-field models, which are based on the diffuse interface approach, have proven useful in simulating and predicting the evolution of microstructures in many material systems. This lecture will first cover the fundamental background of this approach. After several applications are briefly reviewed to demonstrate the method’s broad applicability, recent results on two different areas of research will be discussed: (1) self-organization via eutectic solidification for fabricating large-area optical metamaterials, and (2) battery electrodes during charge/discharge processes, where conflicting experimental observations had led to a conundrum. Both of these examples illustrate the complexity in the evolution of the systems arising from the interplay of thermodynamics, kinetics, and microstructures, as well as other physics such as stress and electrochemistry. The Summer School for Integrated Computational Materials Education, which will take place at the University of Michigan from June 4 to June 15, 2018 will also be mentioned.