

Shape memory alloys (SMAs) have attracted considerable attention in both industry and research. These materials have a wide range of applications, including in the automotive, aerospace, robotics, and biomedical fields. To date, numerous experimental/theoretical/numerical studies have been performed to understand and characterize the complex martensitic microstructures that form in SMAs during phase transformation. These microstructures typically consist of the parent phase austenite and the product martensite phases. Various computational approaches have been employed to simulate martensitic microstructures in SMAs, each suited to a specific spatial scale. Chief among them, the phase-field method is a powerful computational tool that is based on the notion of diffuse interfaces. The method has been extensively employed to predict martensitic microstructures at the intra- and inter-grain scales. However, in view of the fine spatial discretization needed to properly resolve the diffuse interfaces, existing phase-field modeling efforts are often limited to relatively simple representative microstructures. When applied to complex morphologies, these simulations become computationally prohibitive. This limitation underscores the need for a new phase-field modeling framework that can capture intricate microstructural heterogeneities without incurring excessive computational costs. Therefore, the main objective of this project is to develop a novel phase-field modeling approach applicable at large spatial scale. The main idea underpinning the proposed approach is to forgo an explicit representation the microstructural heterogeneities in the twinned martensite phase. Instead, these heterogeneities are embedded into the kinematic and constitutive equations, and accordingly, the twinned martensite phase is treated as a homogeneous phase incorporating the averaged properties of its constituent variants. The novel phase-field model will be applied to simulate a range of complex multi-domain microstructures, namely the wedge-shaped microstructure and the intricate X-shaped microstructure observed in CuAlNi SMA.