# Stress-Induced Martensitic Transformation in Shape Memory Alloys During Nano-Indentation: Insights from Phase-Field Simulations

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Instrumented micro- and nano-indentation is a powerful experimental tool for the characterization of the material behaviour at small scales. It applies also to shape memory alloys (SMAs), which have gained much popularity thanks to their interesting features of pseudoelasticity and shape memory effect. In general, when the SMA material is in the pseudoelastic state, the indentation-induced martensitic microstructure disappears during unloading, and thereby, the load–indentation depth response is the only available experimental data that can be used for material characterization. It thus seems that modeling is the primary means to examine the martensitic microstructure and can be exploited to supplement the experiment.

The phase-field method is an efficient computational tool for modeling the spatially-resolved microstructure at the continuum level. In the present study, a finite-strain phase-field model is developed for multivariant martensitic transformation. The model possesses a number of important features that enables it to provide a physically relevant description of martensitic transformation under nano-indentation. More specifically, the model is formulated in the finite-deformation framework, admits an arbitrary crystallography of phase transformation, and an arbitrary elastic anisotropy of phases (consistent with crystallographic symmetry of phases). The goal in this work is to thoroughly investigate the microstructure evolution in CuAlNi SMA during nano-indentation. In particular, the impact of the crystal orientation on the microstructure evolution and mechanical response is studied. Moreover, we show that the characteristic features of our model are crucial elements to correctly predict the microstructure.