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Homogeneization methods applied to the modeling of shape memory alloys behavior

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Modeling the functional behavior of shape memory alloys (SMA) is a challenge for the development of industrial applications using these materials. Modern concepts developed in mechanics of materials are very well adapted to solve this problem. Due to the specific characteristic lengthscales involved in the SMA behavior several different models must be developed to deal with the physical mechanisms that are responsible to the observed macroscopic behavior. The formation and growth of the different variants of martensite at the crystal level and granular structure and texture effects greatly affect the overall behavior and must be accounted.

The possibility to induce several variants is considered for the definition of constitutive equations for a crystal of austenite undergoing a martensitic transformation. These equations are derived from a kinematical description of the strain mechanism and using thermodynamical concepts. At this point the more difficult aspect is the description of the different classes of interaction, which are observed between martensite variants. The use of interfacial operators allows solving this problem and lead to the definition of an interaction matrix.

The building of strong intergranular stresses during the transformation in polycrystalline material is the second important point to deal with. We propose to determine these stresses using a scale transition method issued from the field theory. Considering each grain as a single crystal, the classical self-consistent framework allows to compute the macroscopic behavior according to the initial crystallographic texture of the alloy considered. Influence of the latent heat of transformation is also described and the strain rate sensitivity observed in superelasticity is captured.

This model is successfully applied to superelastic behavior and non-isothermal loading. The evolution of different microstructural parameters are presented and discussed. Complex loading conditions are also well described and transformation surfaces useful for structure calculations are computed.