Multiscale Modeling of Creep Behavior in Eutectic NiAl-(Cr,Mo) Composites

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KEYWORDS: *crystal plasticity, homogenization, high temperature, creep*

The macroscopic mechanical response of composite materials depends on the properties of the constituents as well as the microstructure, i.e., the spatial arrangement of the constituents. In this talk we focus on the high temperature creep response of a eutectic NiAl-(Cr,Mo) composite [1], which forms domains (eutectic colonies) within which two metallic phases are arranged as ultrafine lamellar structures (see Fig. 1). Mesoscopic creep experiments of individual colonies showed that the minimum creep rate spans several orders of magnitude depending on the load direction relative to the lamination direction. The apparent Norton exponent also shows a strong anisotropy. Both effects are due to an inhomogeneous stress partitioning between the two phases which originates from the lamellar morphology and the high material contrast. In order to model the macroscopic mechanical response of the material system, we make use of a three-scale homogenization scheme involving two length scale bridges. For this, we describe the lamellar microstructure as a periodic rank-1 laminate, which allows for an efficient evaluation of the effective behavior of a single colony. To account for the interaction between different colonies, we use numerical homogenization techniques, e.g., the description of the mesostructure as a Laguerre tesselation [2] with prescribed interface orientation distribution [3] and its discretization using finite elements. After identification of the constitutive laws of the single phases, we investigate the influence of different interface orientation distributions on the macroscopic creep response.

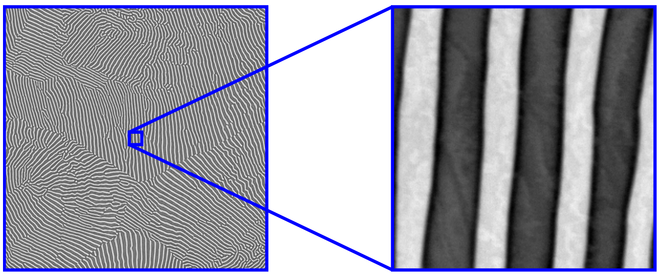

Figure 1. Hierarchical microstructure of NiAl-(Cr,Mo) with eutectic colonies (left) and lamellar structures (right).

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