Martensite textures in deformed NiTi: in-situ measurement and modeling

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Abstract

NiTi shape memory alloys are being used for their ability to exhibit large reversible deformation in response to thermomechanical loading. It stems from detwinning processes in the martensite microstructure with monoclinic B19' crystal structure. The detwinning during loading is characterized by continuous martensite texture changes. Besides applied loading, the texture of the parent austenite cubic B2 phase and the lattice correspondence determine the initial texture of non-deformed martensite. Both the austenite texture and the evolution of martensite texture were evaluated from synchrotron x-ray diffraction recorded in-situ during tensile loading. The macroscopic strain measured during loading of martensitic NiTi results from detwinning of multiple martensite domains inside individual grains. This domain microstructure is formed in austenite single domain grains during the stress free thermally-induced martensitic transformation. The martensite texture evolution during loading reflects the process of simultaneous growth and disappearance of martensite domains as well as the detwinning within the domains. A model is required to retrieve the type of domains and twinning systems involved in the deformation processes inside the microstructure at hands. For this a dimensionless model based on Taylor's hypothesis of macroscopic strain accommodated by individual grains was developed. The model predicts distinct texture evolutions for martensite microstructures based on (001) compound twinned domains and those based on $< 011>$ Type II twinned domains. The textured evolutions simulated for (001) twinned domain microstructure fit well the experimental observations. This conclusion derived from the statistically significant texture measurements is in agreement with local TEM observations on the level of individual grains.

Keywords: Shape memory alloys, martensitic transformation, twinning

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