On the elasticity of twinned martensitic microstructure in nanocrystalline NiTi: Theory and experiment

Macroscopic elastic response of polycrystals is commonly given by the unit-cell elasticity and crystallographic texture. However, NiTi martensite was found to contradict this behavior.
Using ultrasonic methods, we characterized the elastic moduli of nanocrystalline NiTi sample during both thermally and stress-induced transformation. The in situ measurement showed a surprisingly strong anisotropy of the effective shear moduli developing already in the initial stage of pseudoplastic straining under uniaxial loading, suggesting a rather soft and strongly anisotropic R-phase unit cell. This contradicts the current literature and implies an important role of the vicinity of twin boundaries on the unit-cell elasticity of R-phase. Similarly, the self-accommodated martensite (thermally induced) was found softer than its somewhat detwinned (stress-induced) counterpart, the main difference being in shear moduli. The results indicate that the effective elasticity of a martensitic polycrystal is influenced by the amount of twin boundaries present – i.e., by the history of the sample. Such a conclusion resolves the inconsistency of the up-to-date results from calculations (assuming perfect single crystals) and experiments (performed on more or less twinned microstructures).