Microstructural and micromechanical insights into shape memory alloys from *in situ* neutron diffraction experiments at stress and temperature

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This work has benefitted from *in situ* neutron diffraction during uniaxial/torsional loading and heating at Los Alamos National Laboratory and Oak Ridge National Laboratory in carefully selected experiments with shape memory alloys. The first aspect of this work addresses implications for training these alloys (thermomechanical cycling for stable strain recovery in use) and relies on experiments performed under (i) isothermal (both uniaxial and torsional deformation at constant temperature), (ii) isobaric (thermal cycling to temperatures above and below the phase transformation temperatures under constant uniaxial stress), and (iii) isostrain (thermal cycling to temperatures above and below the phase transformation temperatures under constant uniaxial strain) conditions. The second aspect of this work addresses the spatial mapping of thermoelastic deformation mechanisms in non-uniform states of stress in superelastic NiTi, with emphasis on understanding R-phase behavior. The R-phase variants selected by variant reorientation and detwinning processes were equivalent for the corresponding strain (in tension and compression) and the selection of such variants was reversible by isothermal loading. The R-phase variant microstructure was consistent between uniaxial and torsional loading when the principal stress directions of the stress state were considered. The variant microstructure evolution was followed and the similarity in general behavior between uniaxial and torsional loading, in spite of the implicit heterogeneous stress state associated with torsional loading, pointed to the ability of the reversible thermoelastic transformation in NiTi to accommodate both the stress and strain mismatch associated with deformation.