INFLUENCE OF THE LOAD CHARACTER ON THE MARTENSITIC TRANSFORMATION KINETICS IN A TRIP STEEL: A SYNCHROTRON X-RAY DIFFRACTION STUDY

Ercan Cakmak and Hahn Choo
Department of Materials Science and Engineering, University of Tennessee, Knoxville, TN 37996, USA

Ke An
Spallation Neutron Source, Oak Ridge National Laboratory, Oak Ridge, TN 37831, USA

Yang Ren
X-ray Science Division, Argonne National Laboratory, Argonne, IL 60439, USA

Real life material working conditions like metal forming operations frequently involve large strains imposed under complex load paths constituting of shear and axial strains in various combinations. Metastable austenitic stainless steels, very commonly used engineering materials, add up to this complexity by introducing the TRIP effect. TRIP stands for TRansformation Induced Plasticity where the metastable fcc austenite transforms to hcp and bcc martensites under applied strains.

Different slip systems are activated during shear and axial straining. The interactions between these active slip mechanisms are expected to lead to differences in the phase transformation kinetics depending on the mode of deformation because the transformation is closely related to the dislocation activities/structures as dislocation interactions supply nucleation points for martensite embryos. Although there is significant amount of information on TRIP steels under uniaxial deformation conditions, the fundamental understanding of the TRIP behavior under more complex loading conditions is quite limited.

In this study a 304L stainless steel (304L SS) was used which shows the TRIP effect when strained at ambient temperature. The mechanical tests were carried out for i) simultaneous biaxial torsion/tension, ii) simultaneous biaxial torsion/compression, iii) stepwise loading of tension followed by torsion, and iv) stepwise loading of compression followed by torsion. The specimens were studied ex-situ using high energy synchrotron x-ray diffraction with the main goal of understanding the phase transformation kinetics under multi-axial loads (shear+axial) under various load paths. The evolutions of phase fractions and texture (transformation and deformation) will be presented and the different transformation behaviors under various load paths will be discussed. The role of active slip mechanisms on the observed transformation behaviors will be examined and their interactions with the observed texture evolution will also be investigated for possible mechanisms of preferred transformation.