MECHANICAL PROPERTIES AND DEFORMATION MECHANISMS OF MANGANESE SULPHIDE INCLUSIONS

Maximilian A. Wollenweber, RWTH Aachen University
wollenweber@imm.rwth-aachen.de
Carl F. Kusche, RWTH Aachen University
James S.K.-L. Gibson, University of Oxford
Sandra Korte-Kerzel, RWTH Aachen University

Key Words: Micropillar compression, Nanoindentation, Activation volume, CRSS, Inclusion

Manganese sulphide (MnS) is an inclusion common to many kinds of modern steels. They are either introduced deliberately by addition of Manganese to a sulphur-rich melt to increase the machineability of the steel, or unintentionally due to impurities. In either case, MnS inclusions are detrimental to the mechanical properties of the steel by introducing mechanical heterogeneity to the microstructure, which causes the formation of voids during forming, lowering the fatigue resistance. Typically, in extruded materials, such inclusions are distributed lengthways along the extrusion axis, therefore also introducing an anisotropy of mechanical properties and damage formation. Especially under cyclic loading, damage sites whose formation in the microstructure are facilitated by MnS inclusions decrease the performance of the component. In this work, nucleation and growth of damage sites have been studied and correlated with nanomechanical analysis of MnS inclusions. In particular, the inclusions have been investigated with micromechanical testing methods such as nanoindentation and micropillar compression under varying boundary conditions. Additionally, electron backscatter-diffraction (EBSD) on cut out lamellae from deformed micropillars has been performed to gather in-depth information about the active mechanisms of plasticity in MnS inclusions. Resulting from these measurements, the primary slip systems at room temperature could be identified as $\{110\}\langle\bar{1}10\rangle$-type slip systems. In $\{110\}\langle\bar{1}10\rangle$-type slip systems, two slip systems always share the same Schmid factor. The critical resolved shear stress of these systems in MnS has been calculated to be 70.5 ± 2.1 MPa. For slip in the $\{100\}$ planes, which could be activated when choosing an orientation for which the Schmid factor for the primary slip system was low, the CRSS has been found to be 132.8 ± 2.9 MPa.