MM 11: Topical Session: Data Driven Materials Science - Machine Learning for Damage Prediction

Time: Monday 15:45–16:45 Location: BAR 205

Topical Talk MM 11.1 Mon 15:45 BAR 205

From microscopic models of damage accumulation in Ni-base superalloys to the failure probability of gas turbine components — •Tilmann Beck[1], Benedikt Engel[2], Nadine Moch[3], Lucas Mäde[4], Sebastian Schmitz[4], and Hanno Gottschalk[3] — [1]TU Kaiserslautern, Kaiserslautern, Germany — [2]University of Nottingham, Nottingham, UK — [3]Bergische Universität Wuppertal, Wuppertal, Germany — [4]Siemens AG Gas & Power, Berlin, Germany

Conventionally cast (CC) Ni-base superalloys subjected to cyclic mechanical loading exhibit considerable scatter in fatigue lifetime. This is caused by i) a very coarse crystal structure ii) an extremely pronounced elastic anisotropy with Young's moduli (T = 850°C) of approx. E = 100 GPa in [001] and up to 250 GPa in [111] lattice direction and (iii) the fact that fatigue cracks are predominantly initiated in type {111} <110> slip systems of the fcc lattice.

A modeling approach is presented considering anisotropy of E and the Schmid factor m of the {111} <110> slip systems. Based on this, and EBSD analyzes of the actual grain orientation distribution, it is possible to (i) identify crystal grains prone to fatigue cracking and (ii) to explain the major part of the scatter in fatigue lifetime. Using Monte-Carlo simulations of grain orientations, frequency distributions of E and m were determined and collapsed into a damage parameter which quantifies the grain orientation dependent scatter in fatigue life. Using probabilistic approaches based on Weibull's weakest link concept, a model was developed for prediction of the influence of component size and inhomogeneous load distributions on the fatigue lifetime.

MM 11.2 Mon 16:15 BAR 205

Large-area, high-resolution characterisation and classification of damage mechanisms in dual-phase steel using deep learning — •Setareh Medghalchi[1], Carl F. Kusche[1], Tom Reclik[1], Martina Freund[1], Ulrich Kerzel[2], Talal Al-Samman[1], and Sandra Korte-Kerzel[1] — [1]Institut für Metallkunde und Metallphysik, RWTH, Aachen,Germany — [2]IUBH University of Applied Sciences,Bad Honnef,Germany

Dual-phase steels are popular in the automotive industry as they allow lightweight design with high stiffness and good ductility. However, their damage behavior is not yet fully understood and their heterogeneity at different length scales impedes a full characterization based on small excerpts of the microstructure. Understanding their damage behavior therefore requires detailed investigations of many damage sites at high-resolution over large areas. To this end, we have collected a large amount of data by means of panoramic imaging in a scanning-electron-microscope before and after deformation following different strain paths. Machine-learning allows us to tackle the challenges of automated analysis of the microstructure of dual phase steel samples. A deep-learning based algorithm has been developed to classify the detected damage sites in the microstructure. Furthermore, we have now enhanced the accuracy and robustness of our method by data-augmentation, making it applicable on samples which were subjected to different deformation conditions, e.g. uniaxial or biaxial tensile testing. This reduces the need for manual interventions, aiding the high-statistics-microstructural-analysis under variable conditions.

MM 11.3 Mon 16:30 BAR 205

Statistical characterisation of damage sites in dual phase steels under different mechanical deformations — •Setareh Medghalchi[1], Carl F. Kusche[1], Tom Reclik[1], Martina Freund[1], Ulrich Kerzel[2], Talal Al-Samman[1] und Sandra Korte-Kerzel[1] — [1]Institute of Physical Metallurgy and Metal Physics, RWTH Aachen University, Aachen, Germany — [2]IUBH University of Applied Sciences, Bad Honnef, Germany

During last years the increasing demand for high strength and good ductility beside light weight, introduces dual phase steels as a proper candidate for automotive industries. Understanding the failure behavior of these parts requires detailed investigations about the damage sites of its microstructure in high resolutions over the large deformed areas. In our framework, large amount of data are collected by means of automatic panaromic imaging in scanning electron microscope. Taking the advantage of artificial intelligence facilitates us to tackle the challenges of data collection and interpretation of the microstructure of the dual phase steel. A deep-learning based algorithm has been developed to classify the detected damage sites in the microstructure. Furthermore, we have enhanced the flexibility and accuracy of our method to make it applicable on samples which underwent different mechanical deformations like biaxial tensile test. The extended version of this method is invariant with respect to different features of the damage sites (like geometry, orientation, color contrast) which provides statistically relevant mechanisms of damaging that leads to microstructural analysis in addition to the laborious efforts reduction.