THREE-DIMENSIONAL CHARACTERIZATION OF DAMAGE IN DUAL PHASE STEELS WITH DEEP LEARNING

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High performance materials like dual phase steels typically possess a heterogeneous microstructure. Owing to this fact, their properties exceed those of the individual components. High resolution scanning electron microscopy serves as a tool to unravel many of the microscale properties related to the deformation and mechanical properties of these materials. In this regard, damage sites in the microstructure serve as the main controlling feature during deformation.

We know that damage is a stochastic process. Therefore, there are 2 fronts to tackle for a deep understanding: first, bringing high resolution analysis to large scales, and second, moving from 2 dimensional to 3-dimensional characterization.

On the other hand, collection, and analysis of the data from larger areas to analyze the materials behavior requires laborious effort and a considerable amount of time. Development and application of deep learning convolutional neural networks have enabled us to establish sustainable frameworks to collect and analyze the large amount of data collected from large areas by means of which, statistical information about the specific features of the microstructure can be extracted, like damage site locations, type, mechanisms, phase contrast etc. .
In fact, the initiation and evolution of damage has been always a matter of curiosity for materials scientists and designers. With the knowledge of the damage occurring in many sites with different local conditions and in particular, following the three-dimensional stress state, we have combined as many parameters as possible, like large area analysis, 3rd dimension from serial sectioning and different strains. We have therefore extended our method to the third dimension, which assists us to resolve the dominant damage mechanisms in the 3-dimensional stress state accurately.