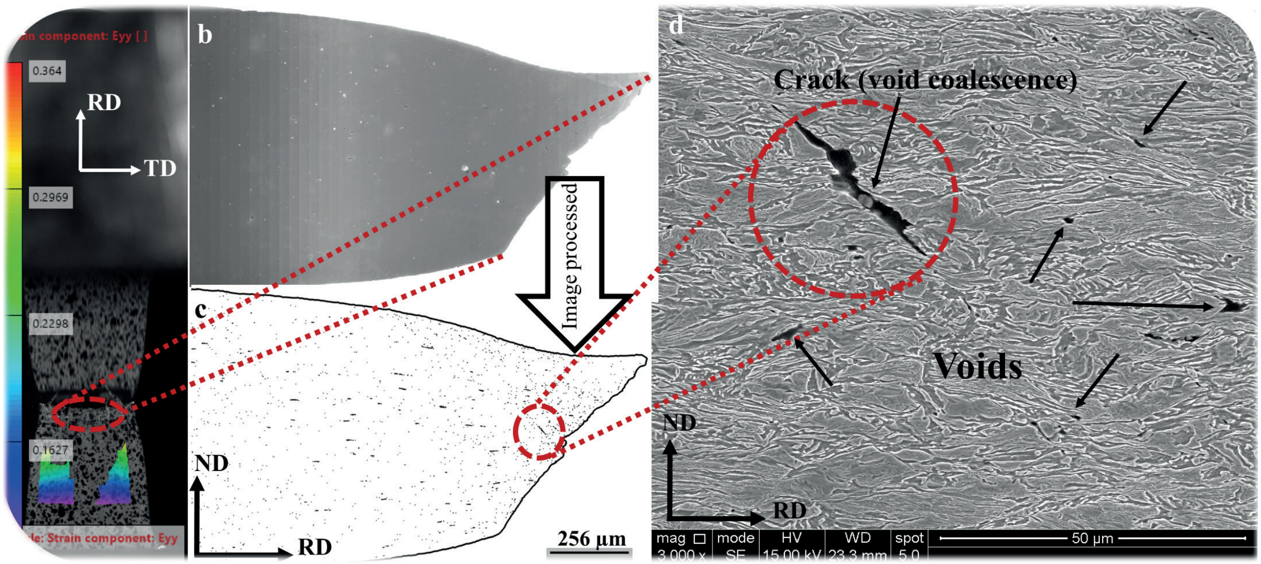
Hierarchical behaviour and failure mechanisms in automotive steel grades



An example of damage mechanisms at different length scales which lead to global failure: (a) a high strain rate (687s^{-1}) tensile deformation of a bainitic steel loaded along the Rolling Direction (RD), (b) contiguous collection of ~1000 SEM micrographs of the fracture sample in (a), (c) the corresponding image processed version of (b) with clear distribution of voids and (d) etched microstructure of the fractured bainitic multiphase steel

Sheet Metal Forming is an important requirement for metal sheet to be employed in automotive applications. Many experiments and simulations are performed in order to predict the forming limits of steel sheets, which are determined either by observation of the sheets' failure or deformation localization during various forming processes. In order to enhance the formability at the macroscopic level, a deep understanding of micro-mechanisms of failure is necessary as well as the hierarchical connection through various length scales.

In the current research work, dr.ir. Behnam Shakerifard, under supervision of dr.ir. Jesus Galan Lopez and prof. dr. Leo Kestens, investigates damage initiation micro-mechanisms under static and dynamic loading by advanced experimental characterization techniques and crystal plasticity based modelling. This research is conducted on the 3rd generation of advanced high strength steels, which are promising candidates for the production of various components of the car Body-In-White.

The topology of 2nd phase constituents at micro and meso-scale have different local and global impact in bainitic multiphase steels. It is shown that earlier damage initiation and higher volume fraction of voids do not essentially lead to earlier macroscopic failure. Moreover, crystallographic orientations susceptible to damage initiation are identified by crystal plasticity modelling and experimentally validated by scanning electron microscopy observations.
Bainitic multiphase steels exhibit a positive strain rate sensitivity, which is desirable for crash worthiness and for improving the forming behaviour. It is shown that any microstructural strengthening mechanisms in steels can decrease the strain rate sensitivity.

The PhD research work of Behnam Shakerifard was carried out at Delft University of Technology in collaboration with Ghent University. Behnam Shakerifard successfully defended his PhD thesis on the 24th of June 2019. The title of his dissertation is 'From Micro-mechanisms of Damage Initiation to Constitutive Mechanical Behaviour of Bainitic Multiphase steels'.

The thesis can be found at:
https://repository.tudelft.nl/islandora/object/uuid%3A230fffcb-b313-4f9f-bec0-e619bc62b0d4