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Multiscale In Situ X-ray Laminography enabling the observation of damage formation in alloy sheets

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Mechanical loading experiments of flat sheet materials allow investigating a broad range of stress triaxialities, including non-proportional loading. This is highly relevant for the understanding of fracture mechanisms under engineering-relevant conditions [1, 2, 3].

In this context, X-ray computed laminography (CL) [4] has proven to be a unique and powerful tool for the non-destructive 3D characterization of such specimens, which due to their non-cylindrical shape are not suited for the application of conventional computed tomography techniques. Here, CL offers a high and laterally isotropic resolution without the necessity of sample dissection, which is crucial for in situ studies. In particular, the screening of large sample areas followed by zooming into selected regions of interest is possible, providing access to a hierarchical view of the sample [1].

Here, we employ KIT's complementary synchrotron CL instrumentation portfolio for a correlative study of the 3D strain damage interactions under varying stress conditions in alloy sheets on the micro- and nanoscale. The in situ CL measurements are complemented by macroscopic in situ surface microscopy-based strain measurements.

The obtained measurements allow us, studying the 3D strain damage interactions under varying stress conditions in alloy sheets on multiple scales. We combine microscale CL and macroscale surface microscopy to study non-proportional loading during so-called 'load path change'experiments from tension-to-shear (see Fig. 1) and shear-to-tension [2]. Subsequently, acquired 3D CL images permit to measure internal strain by means of projection digital image correlation [2] and the morphological development of damage and intermetallic particles. The measured strain fields agree with finite element simulation, confirming non-proportional loading with variable stress triaxialities during the loading experiments. Two types of damage features are observed: cracks in intermetallic particles and flat cracks in the aluminium matrix with sizes typical for grain-boundaries. The observed damage features are further studied by nanoscale CL [1], revealing their nanostructure and dependencies on the material's grain structure.

Figure 1: Microscale snapshot of an in situ CL study of ductile fracture during a tension-to-shear load path change experiment. (a) Strain measured by in situ CL. (b) Corresponding simulated strain field. (c) 3D microstructure of damage within the investigated specimen measured by CL.

I plan to submit also conference proceedings

No

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