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Particle induced void growth under shear observed by in situ laminography in a tension to shear load path change for an aluminium alloy

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Abstract

We report the quantitative 4D characterization of ductile damage formation during a 'tension to shear' load path change experiment in a recrystallized AA2198-T851 alloy sheet. This approach generates significant damage and strain during the tension phase and subsequently quantifies its evolution under shear. It is shown that through the void locking mechanism by broken intermetallic particles void growth occurs under simple shear loading. Characterization is performed using synchrotron-based in situ 3D X-ray laminography, dedicated to investigating regions of interest in flat specimens, and correlative surface imaging. Subsequent analysis by segmentation of the 4D microstructural development and strain measurement via projection digital image correlation quantifies relevant damage processes inside the sample bulk. Damage features identified are either grain- or intermetallic particle-related. Grain-related damage features are found to be detrimental, exhibiting a volume growth by a factor of one and a half under shear. For specific grain-related damage features, spatially coinciding with the fracture path, a doubling of the volume under shear is observed. During the shear phase, additional notch-like damage features at the sample surface play an important role in fracture, developing under high or under low stress triaxiality values. Intermetallic particle-related damage is found to play a less prevalent role in fracture but shows a remarkable volume increase by a factor of five under shear. To understand further this unexpected void growth under shear, 3D simulations of the meshed broken particles are performed in shear, using the boundary condition from DIC of the experiment and also idealized boundary conditions for simple shear. Both confirm particle induced void growth under shear.

Keywords:

ductile damage particle shear laminography finite elements