ESRF	**Experiment title:** In situ imaging of damage evolution during non-proportional load path changes	**Experiment number**: 2018ma4333
Beamline: ID19	**Date of experiment**: from: 28/11/2018 to: 30/11/2018	**Date of report**:
Shifts:	**Local contact(s)**: Dr. Lukas Helfen	*Received at ESRF:*

Names and affiliations of applicants (* indicates experimentalists):

*Dr. Thilo Morgeneyer, Mines ParisTech

*Xiang Kong, Mines ParisTech

*Dr. Daniel Haenschke, KIT

*Mathias Hurst, KIT

*Andrei Shkarin, KIT

*Rebecca Pretzsch, KIT

In order to study the load path change effect on two kinds of light Aluminium alloys AA2198 T8R and AA2139 T3R, 3 different non-proportional loading in-situ experiments of 2 materials (see Table below) were planned to be conducted using laminography at beamline ID19.

Table.1 Initial experiment plan under 3 loading conditions of 2 materials.

	Shear-Tension	Tension-Shear	Tension-Tension
AA2198 T8R	**1**	1	1
AA2139 T3R	1	1	1

Due to control and encoder problems of the laminography station only one Shear-Tension test on AA2198 T8R was conducted. 5 or more tests need to be done. The test started at 0:42 am on 29 Nov 2018, after 10 (shear) and 13 (tension) scans shown in **Fig.2** at high resolution (650 nm/pixel), the linear encoders that control the position of laminography station were out of service at 7:00 am on 29 Nov 2018 and we lost the position. The system was recovered at 21:00 and much time was spent. Finally, two more scans were taken on this experiment before the fracture at low resolution (1460.25 nm/pixel). The raw volume size is 2560×2560×1500 voxels for each scanning. The dedicated motorized *in situ* tensile machine (Fig.1) worked successfully.

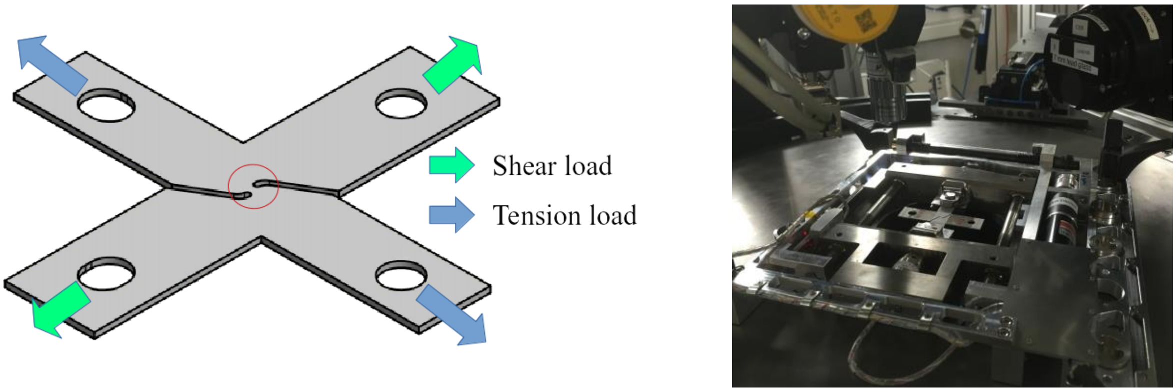

Fig.1 Drawing of Shear-Tension cross sample (left) where central part is in red and loading machine with a cross sample on laminographic table at ID19 (right).

Result

The loading history and scan points are shown in **Fig.2** during the scanned experiment. Finite element model is created to simulate the same non-proportional Shear-Tension experiment where the blue line stands for simulated results in **Fig.2**. The accumulated plastic strain fields at every scanning step are obtained where finally the strain to fracture can to be read. The damage evolution is observed from selected volume (yellow frame: 1600×1000×1100 voxels) at typical 4 steps in **Fig.3** where the voids are observed to nucleate and grow during the shear loading and the tracked voids subsequently continued to grow under tension till fracture. Strain was measured in the material bulk using 2D sections of projected 3D data.

Based on the laminographic experiment, the results have been shown as poster at two symposia and the lecture will be presented at different conferences this year (ECF23, ICCA17, WCCM-ECCOMAS2020). Currently a paper entitled “Effect of a shear to tension load path change on damage mechanisms and strain to fracture: 3D in situ measurement and FE analyses” is in progress.

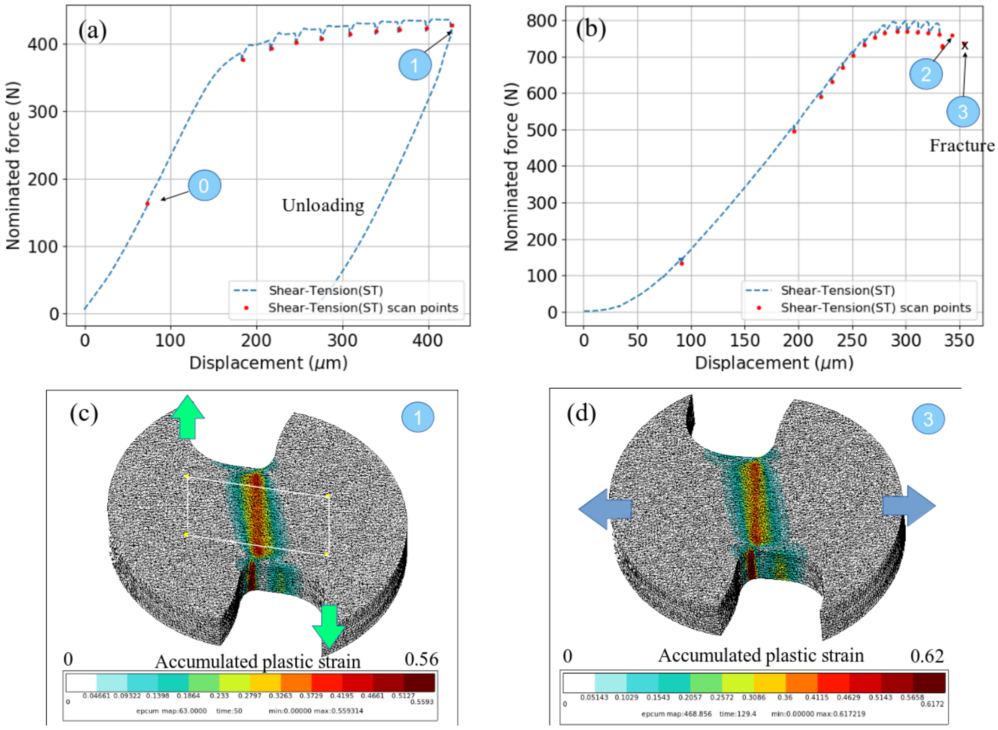

Fig.2 Displacement (μm) – Force (N) curves load history (blue) and scanning (red point) during (a).Shear to (b).Tension test. Accumulated plastic strain fields from FEM on simulated model central part are shown at (c). end of shear period and (d). end of tension period.

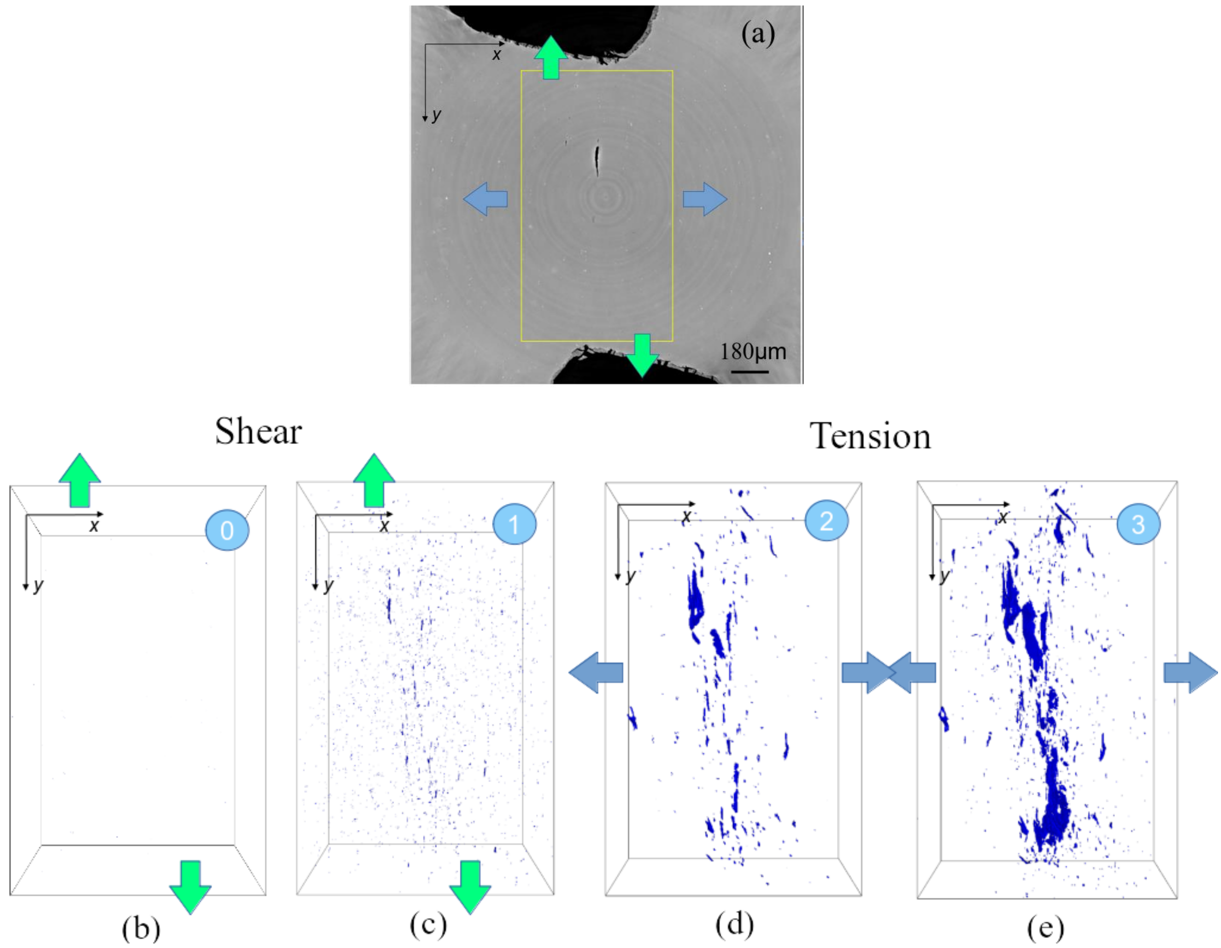

Fig.3 (a). Scanned volume slice where the interested region is selected in yellow and the damage evolution under non-proportional loading from (b). shear beginning, (c).shear end, (d). last second tension end to (e).tension end step.