EUROPEAN SYNCHROTRON RADIATION FACILITY

INSTALLATION EUROPEENNE DE RAYONNEMENT SYNCHROTRON

Experiment Report Form

	Experiment title: Damage accumulation during themo-mechanical fatigue of Al-Si piston alloys	**Experiment number**: MA2994
Beamline: ID19	**Date of experiment**: from: 21.4.2016 to: 24.4.2016	**Date of report**: 6.3.2018
Shifts: 9	**Local contact(s)**: Elodie Boller	*Received at ESRF:*

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Report:

The tensile behaviour at elevated temperatures of different Al-Si piston alloys with ~12 wt% of Si and varying contents of Cu (3-5wt%), Ni(2-3%) and Mg (0-1wt%) was investigated by means of interrupted in-situ synchrotron tomography at the beamline ID19. Table 1 shows the used parameters for these experiments.

Energy: [keV]	FOV: [mm2]	Voxel Size: [µm³]	Sample-to-Detector: [mm]	Nr. of projections:	Exposure Time: [sec/proj]
19	1 x 2	$(1.1)^3$	150	1000	0.01

Table 1: parameters used for synchrotron tomography

Tests were carried out using an in-situ HT tensile rig provided by INSA de Lyon with strain rates of 0.1µm/sec at test-temperatures of 300°C and 380°C. Controlled heating of the specimen central section was applied by induction.

The aim of these experiments was the identification of crack initiation sites, crack propagation and damage accumulation during tensile deformation of Al-Si piston alloys as well as the determination of microstructural features affecting the mechanical behavior. The obtained stress-strain curves revealed, that, in general, all tested alloys showed decreasing tensile strength and increasing ductility with increasing test-temperatures. Alloys with greater amounts of Cu and Mg and additions of Zr, Ti, V showed higher tensile strength and less elongation at failure. Fig. 1 shows a 3D visualization of the damage formation and accumulation at several deformation steps on the example of an AlSi12Cu4Ni2Mg alloy. Damage was initiated through debonding and micro-cracking in primary Si-clusters and also through damage initiation in the matrix in the vicinity of rigid phase/matrix interfaces in shape of voids. Cracks were always oriented perpendicular to the load direction. Shrinkage porosity (see Fig.1 (a)) could be observed in more Cu-rich alloys, but do not play a noticeable role during damage formation. Final failure of material occurred due to a coalescence of earlier formed cracks and voids. The main crack propagates along pre-existing damage, rigid phases and - contrarily to room temperature observations - also through the Al-matrix. A quantification of damage revealed a higher accumulation of damage for alloys with large, irregular primary Si particles and primary Si clusters in their microstructure.

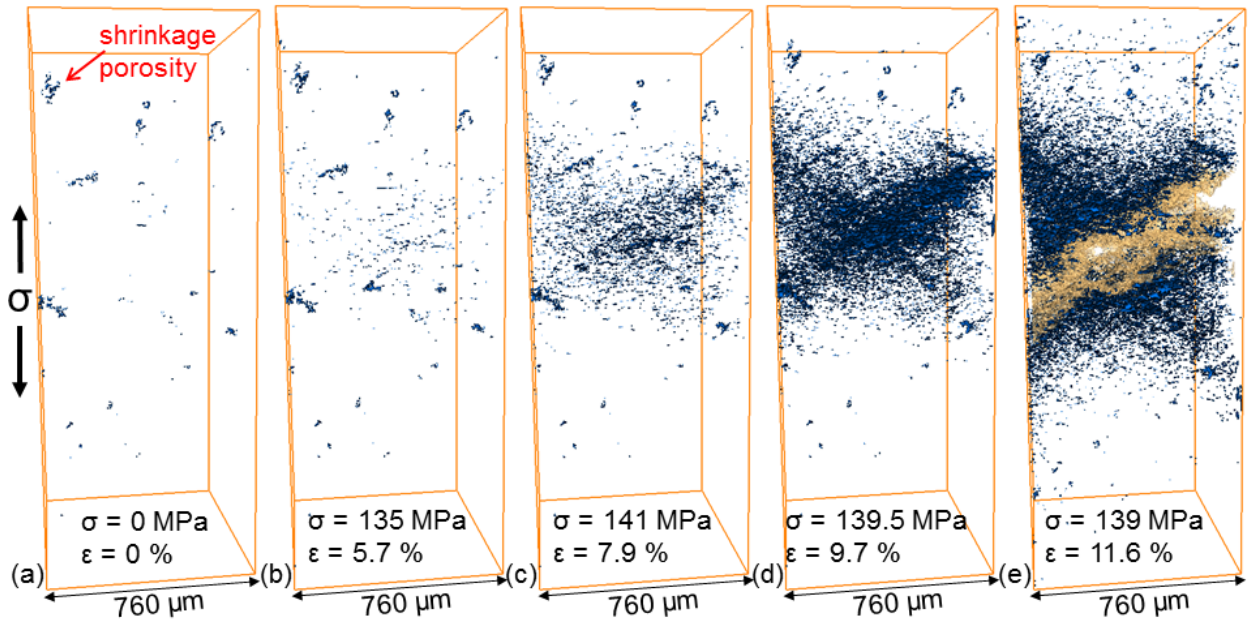

Fig.1: 3D visualization of damage accumulation (blue) near the fracture surface (brown) of an AlSi12Cu4Ni2Mg alloy during the interrupted tensile tests at 300°C: a) initial condition b) at 135 MPa and 5.7% elongation, c) at 141 MPa and 7.9% elongation, d) at 139.5 MPa and 9.7% elongation, e) post-mortem after 4h ST. The load direction is vertical.

There were no major difficulties encountered during the experiments.
With the described experiments and results, adequate data concerning in-situ tensile tests could be obtained.
Elodie Boller, our local ESRF/ID19 contact during the experiments will be included as co-author in foreseen publications.