ESRF	**Experiment title:** In situ nanodamage and strain interactions: three-dimensional multiscale in situ laminography experiments and simulations	**Experiment number**: Ma2787
Beamline: ID16B	**Date of experiment**: from: 24 march 2016 to 29 mars 2016	**Date of report**: 03/2018
Shifts: 12	**Local contact(s)**: Jussi-Petteri Suuronen	*Received at ESRF:*

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Report:

During this experiment we observed successfully under load, i.e. in situ, the nucleation and propagation of a ductile crack in a notched sheet Aluminium sample. The observations were made at different scales:

1. a surface image was taken to identify the macroscopic sample opening and displacements
2. a single-distance scan of the material ahead of the notch with a pixel size of 240 nm was taken
3. a hololaminographic scan (4 distances) was taken to be able to reconstruct the data with a pixel size of 100 nm

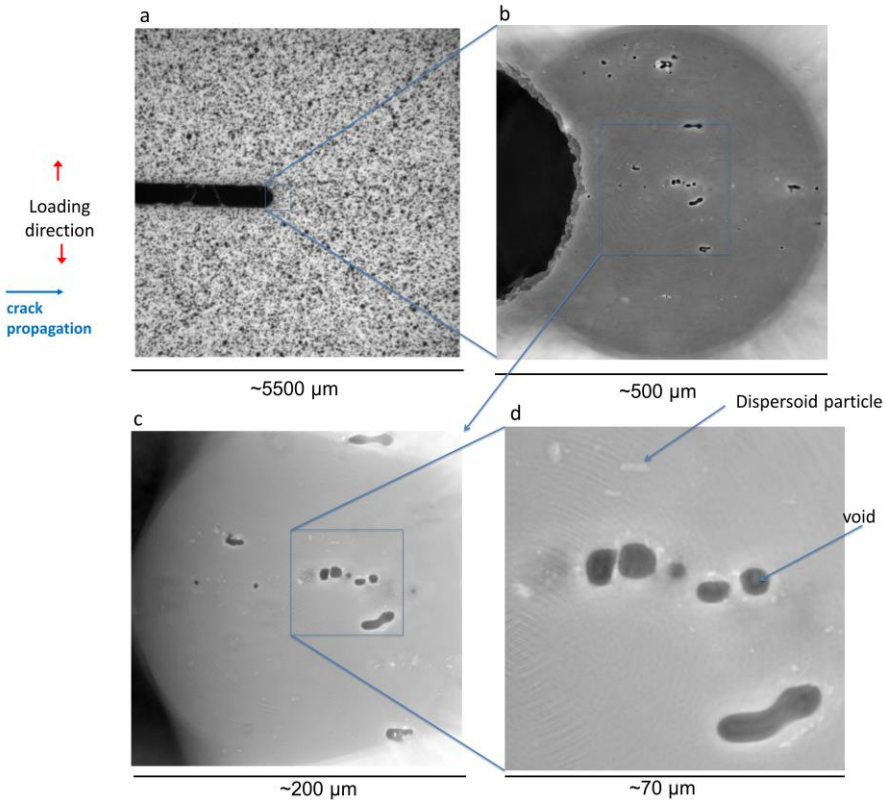

Figure 1: Multiscale assessment for the initial state: a) 2D surface image for DIC of the notched sample surface b) 2D mid section of 3D laminography data at the notch c) zoom showing 2D mid section of 3D nanolaminography data after hololaminographic reconstruction of 4 scans d) zoom in the 2D nanolaminography section

Several load steps were successfully applied until failure. The screw driven in situ device had been designed especially for this experiment and only weighs 40 g including the sample. The in situ

device and the laminography set-up that had been transferred from id 22b were validated. The data was reconstructed.

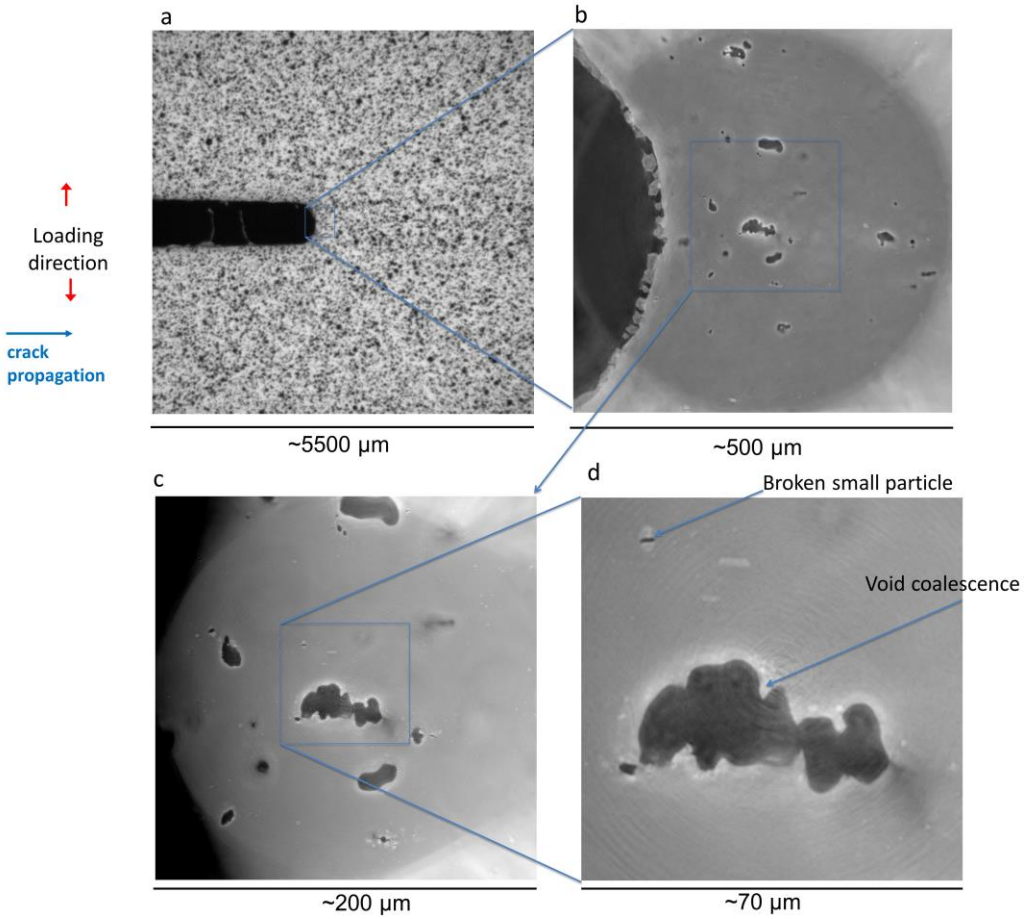

Figure 2: Multiscale assessment for a loaded state; sections are given at the same locations and resolutions as for figure 1

It is shown in figure 1 for the unloaded state and for the loaded state (figure 2) in terms of 2D sections. The gain of resolution in the holotomographic scan is clearly visible. Small dispersoid particles can now be discerned. Their fracture is seen for the loaded state (figure 2d). The particles reveal to be useful markers for digital volume correlation. Digital volume correlation allows to track contrast and determine 3D displacement and strain fields in the material bulk. First attempts for DVC revealed to be successful. Hence local strain information will be gained at multiple scales for comparison with finite element modelling.

A PhD student is currently working on the optimized reconstruction and segmentation of the data to identify damage nucleation and growth kinetics. Different phase reconstruction algorithms are tried including a quasi particle approach to identify the quality improvement of the hololaminographic scan compared to a single distance scan. This work is will be included in the first journal publication on this experiment.

Publications

A finished PhD thesis by Ante BULJAC contains some initial results from this experiment (p341-345).
https://tel.archives-ouvertes.fr/tel-01617107

A paper on the in situ multiscale approach and reconstruction procedure will be submitted this year (Several other papers containing unprecedented information on mechanics of materials will be written in the forthcoming years).

A patent (draft) concerning the in situ loading device is under assessment at the CNRS.