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Experiment Report

Tomographic investigation of the coupled mechanism of creep-cavity growth

Preliminary experiment report ma1351

The proposal ma1351 has been submitted on the 1st March 2011, it has been received "very well" by the scientific committee, but no beamtime has been allocated. The proposal contains two experimental innovations aiming a generalization of microtomography to creep damage studies by:

a) the use of samples with larger diameter for in situ studies (on ID15A) and
b) tomography on interrupted test specimens deformed in the home laboratory.

The first point had the aim of evaluating the growth rate of a higher number of creep cavities by implementing the wide field tomography [1] at ID15A.
The second point facilitates the development of a software basis that enables to correlate consecutive volumes measured on the same sample, but deformed ex situ in the home lab during the time between the measurements. The advantage of this second aspect is enormous since it will allow performing void growth studies on samples creep deformed under more realistic conditions (closer to conditions found in real applications). Since these measurements are planned to be done ex situ it is evident that such scans are better suited for ID19, where better optics is available.

The innovations have been well received by the beamline scientists and thanks to them we got **preliminary beamtime for feasibility studies** of the proposed new experimental conditions. Both are important for the success of the planned work on combined growth mechanism, which requires samples deformed in situ and ex situ.

Results
Based on measurements performed on ID15A an algorithm has been developed in Matlab code for wide beam tomography. Such a reconstruction of a copper sample with diameter of 1.8 mm (pixel size 1.2 μm) is shown in fig. 1.

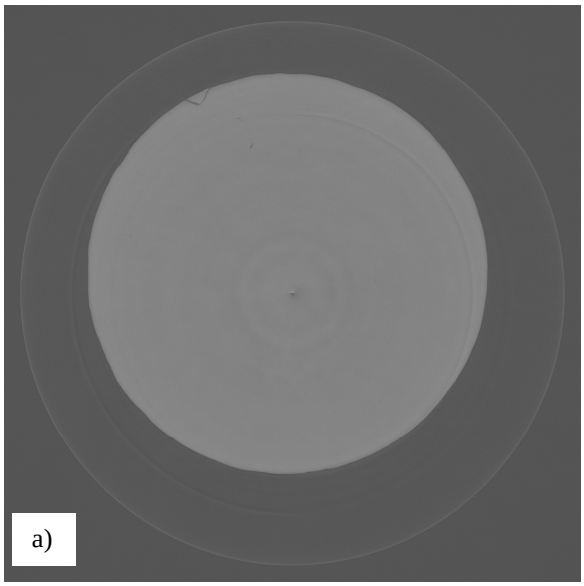

Fig. 1. Wide field reconstruction of a copper sample performed on ID15A (8000 projections, image size 2000 x 2000. Detector pixel array 1k x 1k).

For comparison reasons the same sample has been measured on ID19 again under pink beam conditions using a 2k x 2k Frelon detector (no stitching was necessary in this case) and a similar pixel size as for ID15A. Unfortunately, the allocated beamtime was just after the replacement of the damaged translation stage and the beamline was not in good operating conditions. We had major problems due to the dirty scintillator (and due to the lack of a new one) as well as due to the dirty reflection mirror of the X-ray detector (a new mirror was available, but its quality was much worse that that of the dirty mirror!). The worse quality of the ID19 reconstruction compared to that on ID15A is visible in fig. 2, which shows the same material slice of the copper sample, but reconstructed at two different beamlines.

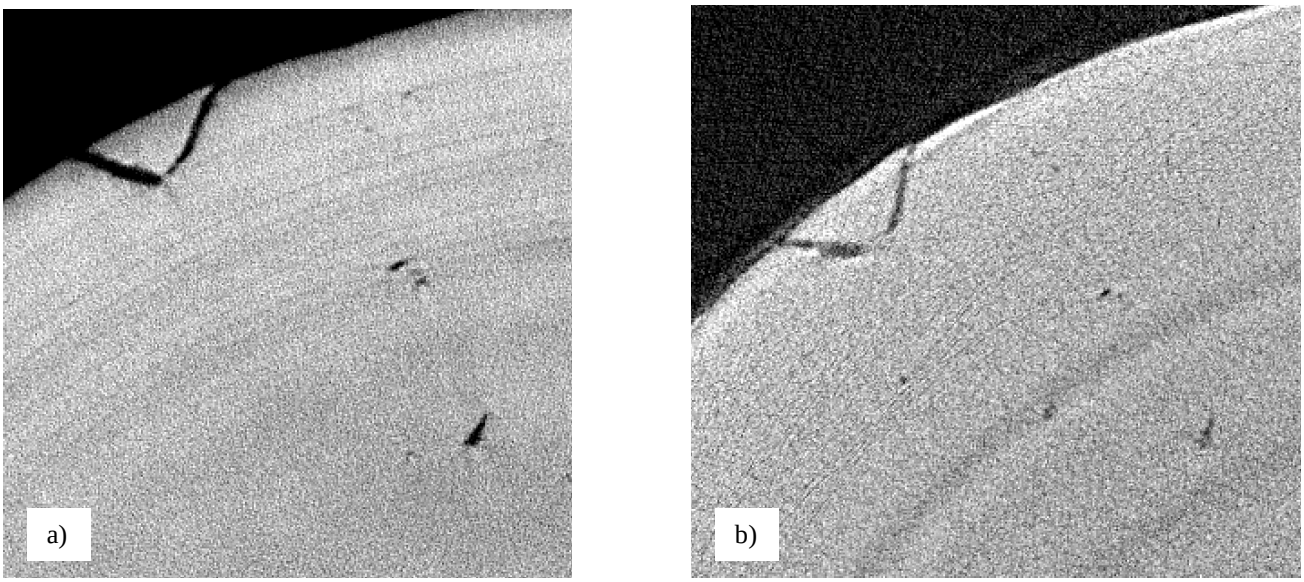

Fig. 2. The same material slice of a copper sample with 1.8 mm diameter reconstructed on ID15A (a) and ID19 (b)

In spite of the less successful measurement on ID19 we can state that the preliminary beamtime was successful form the point of the project since the initial aims were attained:

a) the wide field tomography software has been developed (is available on request from the main proposer)
b) we could set up a reliable sample manipulation procedure that allows finding the sample regions (creep cavities in this case) in reconstructions performed at different times and even on different beamlines (Fig. 2)

c) we could also clarify that pink beam conditions are not optimal for void growth studies on ID19. Therefore such scans in the future will be performed on smaller samples of about 0.7 mm in diameter and will be measured with a more monochromatic beam (using a multilayer). Such measurements led in the past to very good reconstructions for brass [2] and steel [3, 4], where the creep cavities could be well segmented.

The proposed measurements will be part of the thesis of Ramin Abbasi (Ecole des Mines de Saint-Etienne), who is now at in the 2nd year of his formation.

References

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3. A. Isaac, K. Dzieciol, F. Sket and A. Borbély,"Microtomographic Characterization of Single-Cavity Growth During High-Temperature Creep of Leaded Brass", Met. Mater. Trans. A, 42 (2011) 3022-3030.
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