REPORT _IN_705

This study is the continuation of experiment ME-566. Indeed, in this report we propose to analyse laser-impact metals at higher strain rates ($>10^7$ s^{-1}). In addition, in experiment IN705 we perform X-ray tomographic analyses on samples cut from laser-shocked, monocrystalline tantalum targets. Tomography was carried out on the damaged samples at beamline ID19. One of then was analyzed more specifically. These results were compared to molecular dynamics calculations. These results have been presented at two conferences [2],[3], in a recent student thesis [4] and will be presented in future publications.

The sample was cut to an optimal cross-sectional size of about 250 µm*250 µm. Measurements were carried out using an energy of 52 KeV. We have produced virtual images using a voxel size of 0.7 μm^3, resulting in heterogeneous slices. Because we focus on the evolution of small pores in the early stage of damage formation, we underestimate large spall (which occurs later and upon rupture) compared to small pores.

Figure 1 illustrates the analysis process. This segmentation transforms the original slice into a binary image.

The 3D representation of the damaged volume is displayed in Figure 2 and shows that spall and pores are ellipsiodal in shape. As a preliminary control, we had cut a part of this target to verify the damage. This is the reason that we see only the second part of the ellipsoidal spall. The shock is oriented and propagates along the X-axis. Damage propagation occurs along a perpendicular axis (Y-axis). At a small scale (Fig. 3), isolated pores are also seen to be ellipsoidal.

With these results, we examine the spatial distribution of voids according to the J. Hoshen and R. Kolpelman algorithm [5] and like previous experiment (ME-566).

Molecular dynamics (MD) calculations are used to predict the response of the single-crystals to laser-shock. In Figure 4 we compare calculated curves with experimental results.

At 69 ps, we observed that the calculated curve is stable and doesn't change after this time. Then, we compare this state to the stage of our sample from the recovered-target. The slopes determined from the experimental curves (1.5 and 2.5) are in close agreement with those determined by molecular dynamics (1.4 and 2). These distribution laws correspond to growth and coalescence phases.

Thus, the characterisation of 2 phases of ductile damage is possible with X-ray microtomography at the ESRF. Moreover, analyses of more samples are necessary to confirm the distribution laws established here.

Figure n°1

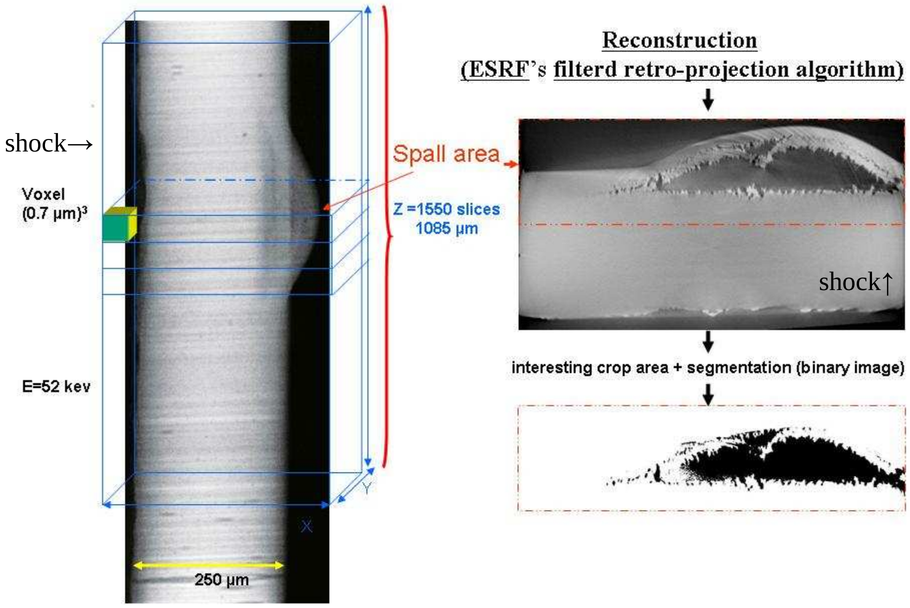


Fig.1 X-Ray radiography of spalled monocrystalline tantalum sample and an example of one slice that has been reconstructed and treated.

Figure n°2

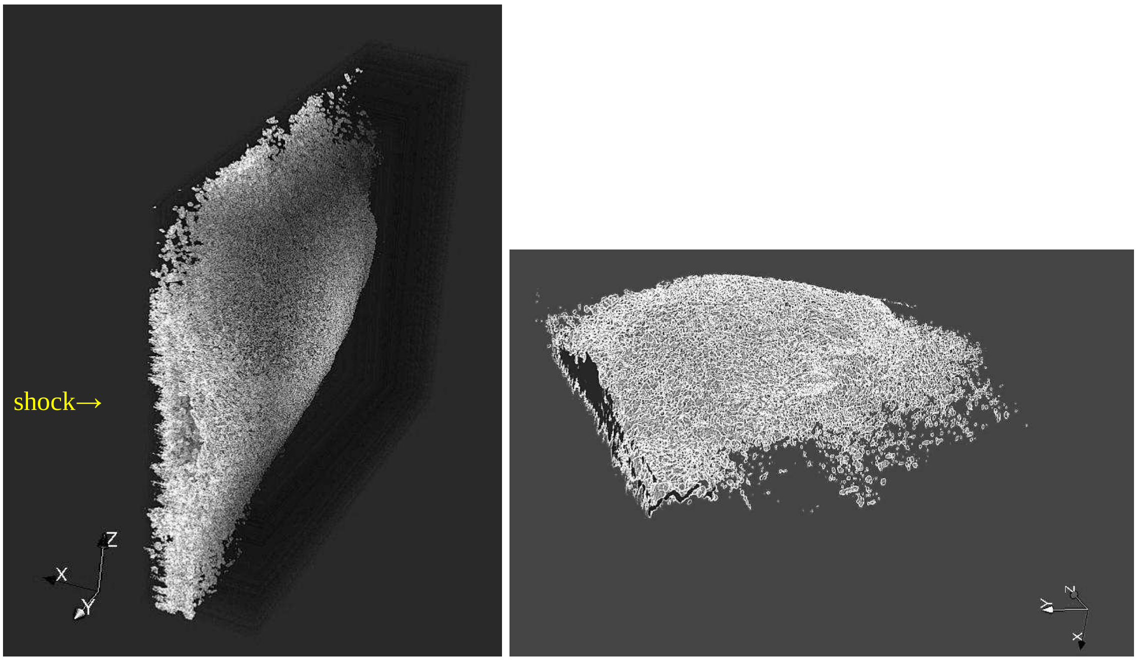


Fig.2: 3D representations of pores.

Figure n°3

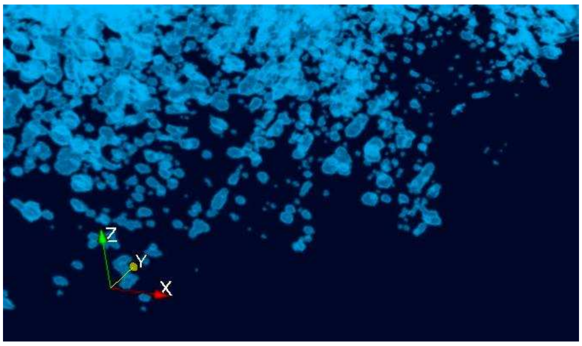
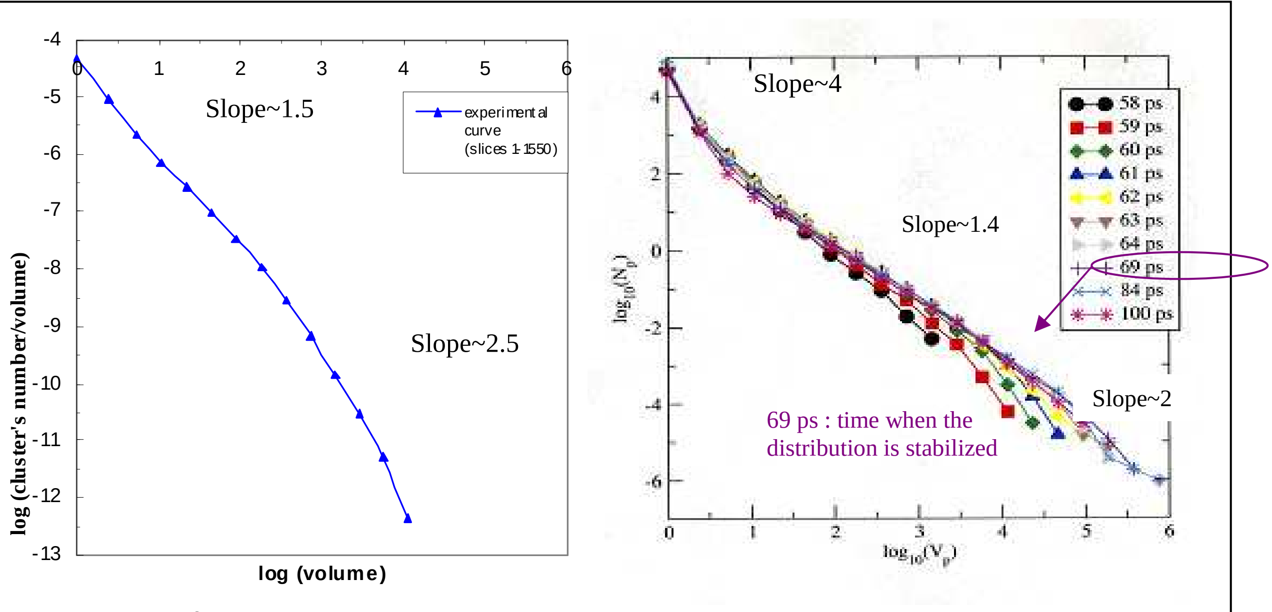


Fig 3: Ellipsoidal shape of pores

Figure n°4



69 ps : time when the distribution is stabilized

Fig.4: Curves of binned pore size distribution - comparison between experimental and MD calculation results.

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