ESRF	**Experiment title:** Imaging small voids during the rupture process of metals using nano-scale tomography	**Experiment number**: MA1026
Beamline: ID22	**Date of experiment**: from: 08/07/2010 to: 12/07/2010	**Date of report**: 14/10/2010 *Received at ESRF:*
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Report:

1. Experiments

Ex-situ tensile tests have been carried out on different kinds of metals:

- Multiphased steels (Dual-Phase steels and FeTiB2)
- Aluminum alloys

The tensile machine was the usual rig used for in-situ tensile test on ID19 or ID15 and provided by the laboratory MATEIS – INSA Lyon. The specimens used were notched to localize damage in the scanned area. The samples sections were 0.3x0.3mm for steels and 0.7x0.7mm for aluminums. An average of three scans per specimens were performed: one before deformation and two at strain steps similar to those indicated in Fig.1.

Each acquisition was in fact composed of two scans :

- a low resolution scan (voxel size =0.3µm) to have a view of the entire specimen that we use to calculate specimen deformation and the triaxiality.
- a local holotomography scan (at four values of the distance) with high resolution (voxel size = 100 nm or 50 nm).

The total acquisition time was about 1h15min.

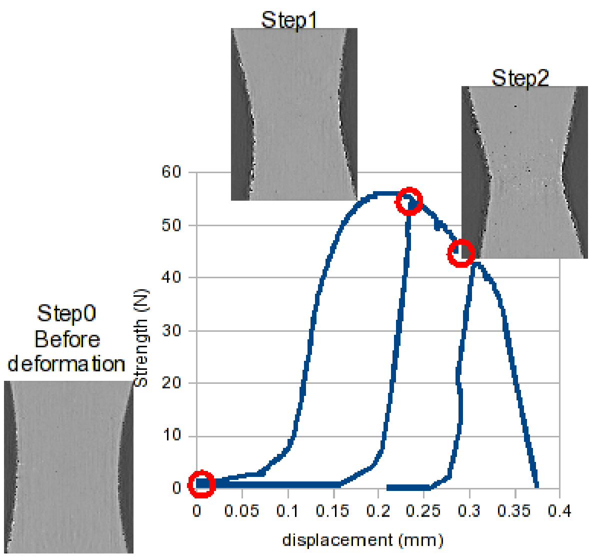

Fig.1. Ex-situ tensile test on DP steel specimen.

2. Results

2.1 Microstructure contrast in DP steels

With X-ray absorption tomography, the contrast between ferrite and martensite cannot be observed because the densities of ferrite and marteniste are too close to each other. Thanks to phase contrast used in holotomography, we have now proved that it is possible to have a contrast and to distinguish the ferrite and the martensite as seen on Fig.2(a). The martensite appears in dark grey and the ferrite in light. A 3D view of the microsructure is also possible (Cf Fig.2(c)). However, this contrast is visible only for the initial scan before the tensile deformation because when voids start to appear, they modify strongly the contrast.

2.2 Damage quantification

The procedure usually used to quantify damage and described in Refs [1,2] was carried out on high resolution scans. The quantitative data is the evolution with the strain of the density of cavities and the evolution of the equivalent diameter of cavities during the tensile test. These evolutions are compared with data coming from same experiments performed on ID15 with a voxel size of 1.6µm. As expected, the void density (Fig.3(a)) measured on ID22 is much higher that one measured on ID15 because smaller cavities are detected on ID22. The average of the equivalent diameter over the entire population (Fig.3(b)) is also smaller in data from ID22 for the same reason. The average of the equivalent diameter over the 20 largest cavities (Fig.3(c)) is also smaller on ID22. This difference is probably due to the more important partial volume effect on ID15.

References

[1] E. Maire, O. Bouaziz, M. Di Michiel, C. Verdu. Acta Mater. 56 (2008) 4954-4964.

[2] C. Landron, O. Bouaziz, E. Maire, J. Adrien. Scripta Mater. 63 (2010) 973-976.

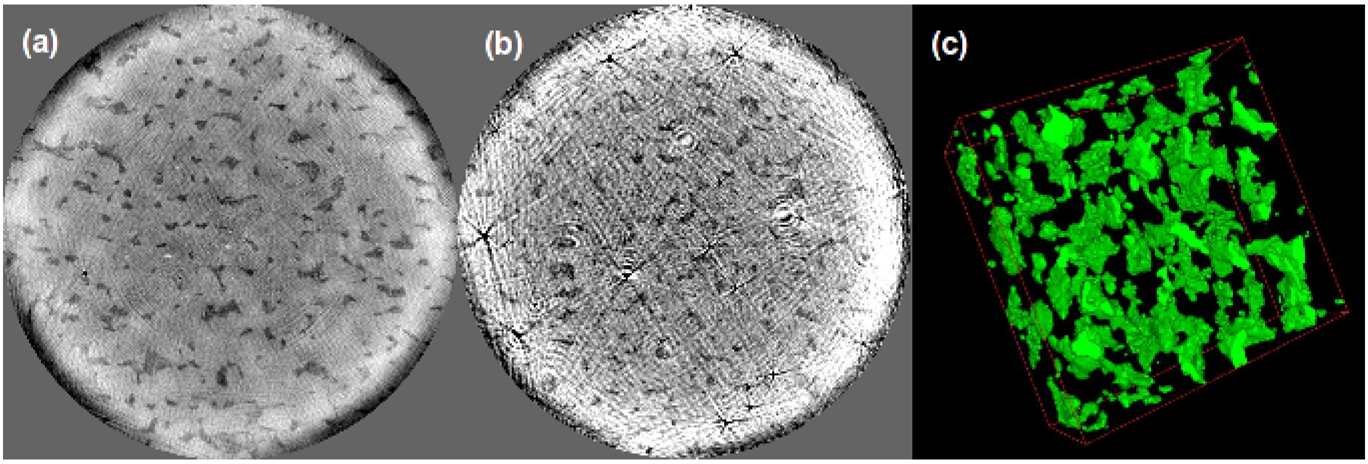

Fig.2. (a) Microstructure contrast in DP steel before deformation, (b) after tensile deformation, (c) 3D view of the martensite phase in the initial state (extracted form figure a).

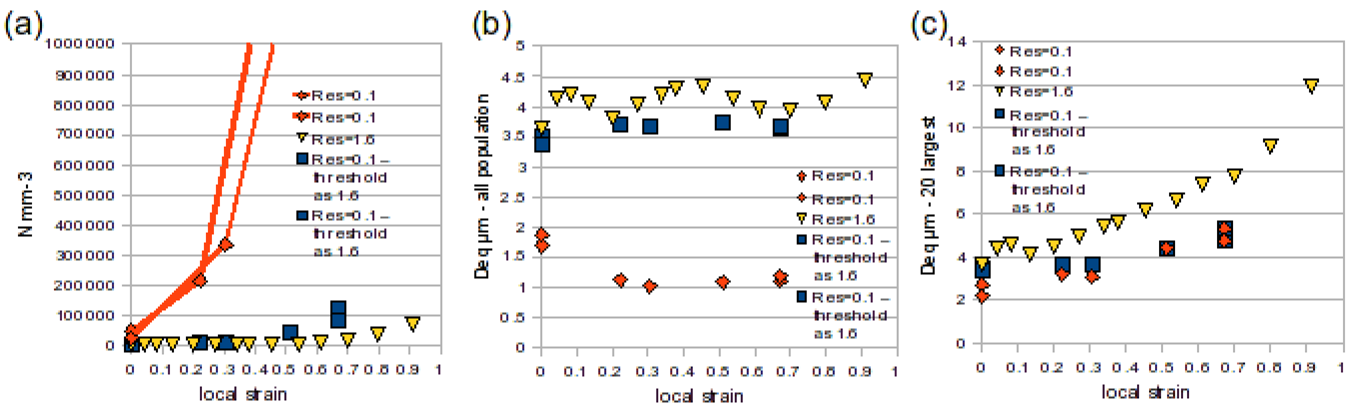

Fig.3. ID22 data comparison with ID15 data (a) void density, (b) equivalent diameter of all the void population, (c) equivalent diameter of the 20 largest cavities.