ESRF	**Experiment title:** Characterisation via x-ray tomography of changes in the cellular texture of an open-cell flexible polyurethane foam during macroscopic compression.	**Experiment number**: SC-564
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Shifts: 9	**Local contact(s)**: W. LUDWIG, E. BOLLER and J. BARUCHEL	*Received at ESRF:*

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Report:

The purpose of this experiment was to use x-ray tomographic imaging to examine the precise mechanisms by which a flexible foam material deforms under a compressive load.

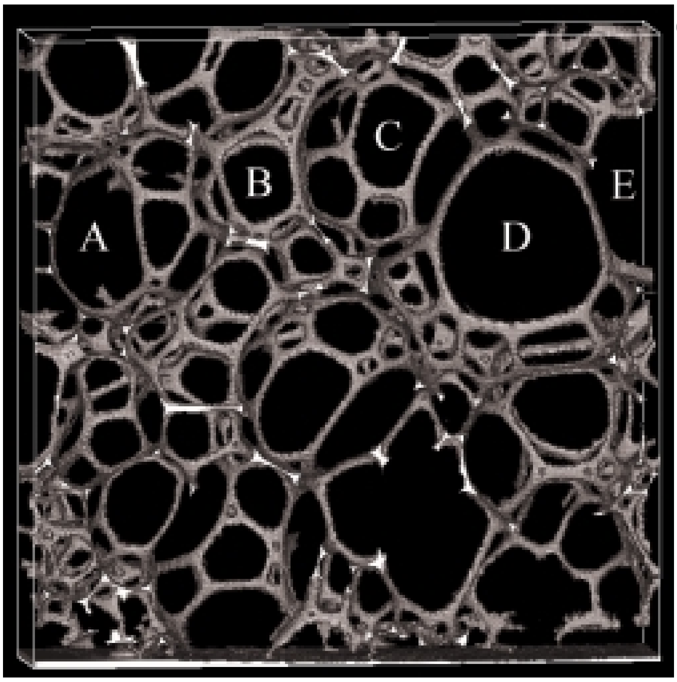
The x-ray tomography experiment sucessfuly visualized the precise mechanism by which flexible poly(urethane) foams deforms under a compressive load. Three different types of foam were imaged. Each foam sample was imaged at 14 levels of compressive strain (0, 2%, 4%, 6%, 8%, 10%, 23%, 25%, 27%, 40%, 63%, 65%, 67%, 80%).

For each compression level, 800 projection images were recorded. The X-ray beam energy was 9keV and the resolution recorded at the detector was 6.65µm. Each projection scan took 4s. The cylindrical foam samples, typically 25 mm in diameter and height, were compressed inside a highly polished perspex tube by a plunger driven by a stepper motor. The control of this stepper motor was integrated with the crate electronics of the beamline. This system of advanced control allowed fully automated tomography scans of each foam sample at the different levels of compression. The high level of automation facilitated the collection of 14 complete datasets without user intervention over a period of approximately 18 hours, representing a highly efficient use of the 9 shifts of beamtime allocated for the experiment.

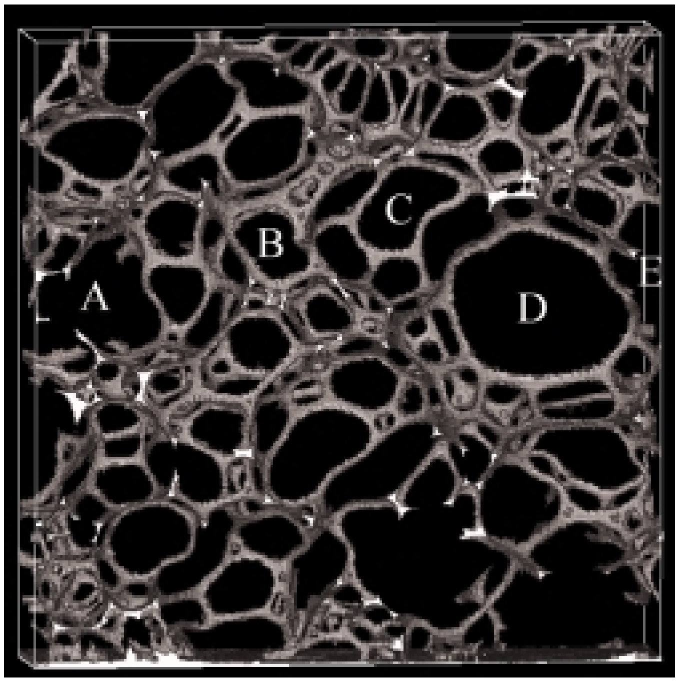
The 3D voxel data was reconstructed using software provided by Dr F Peyrin of ESRF.

Following the reconstruction of the voxel data it has been immediately possible to examine how individual foam struts deform under a compressive strain. Figure 1 shows 3D reconstructions of one foam sample at three different strain levels.

(a)



(b)



(c)

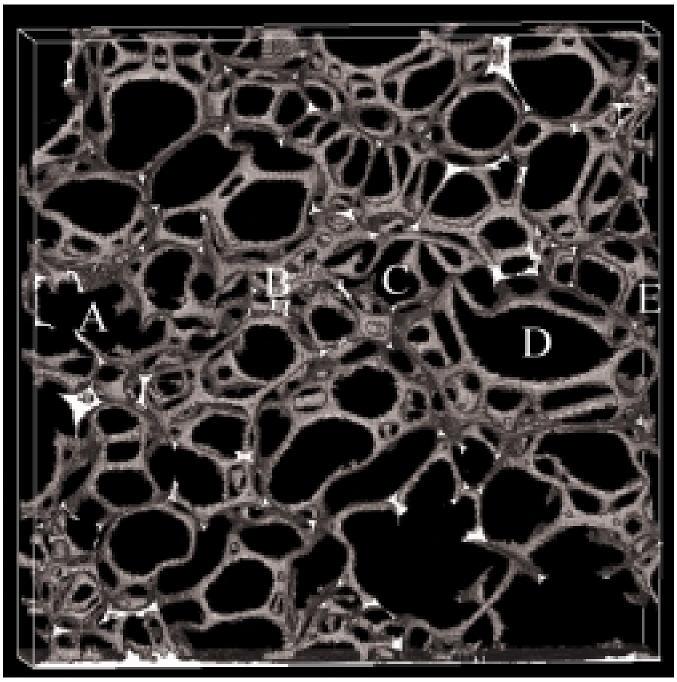


Figure 1: Reconstruction of an open-cell flexible polyurethane foam at several levels of compressive strain. (a) 0% applied strain, (b) 10% applied strain, (c) 23% applied strain. The 3D renditions represent volumes of 7mm x 7mm x 1.4 mm. The face of the stationary plunger can be seen at the bottom of each image.

A comparison of the struts around the cells marked C and D between Figure 1a and Figure 1b shows clearly that the initial phase of the compression occurs by a process in which struts bend. This early deformation is accompanied by a roughly linear elastic response of the macroscopic foam sample. By comparing Figure 1b and Figure 1c it can be seen that a whole band of the structure comprising cells labelled A to E actually collapses. A plateau in the stress strain curve accompanies this second mode of deformation. This experiment has allowed these processes to be visualised in the bulk in unprecedented detail and will allow further clarification of the precise mechanisms of foam deformation.

One of the objectives for this investigation was to compare computer models of the deformation process with the actual deformation process. To this end, the voxel data for the uncompressed samples has been subjected to a further level of image analysis to convert the voxel data into a graph of the struts and their connectivity. This has been achieved in an automated fashion using software developed by Sébastien Bouchet of ESRF. Work is ongoing to examine the way that these structures deform in Finite Element models and to compare the simulated results with the experimental observations.