X-ray Tomography

MANCHESTER 1824
The University of Manchester

STRESS & DAMAGE CHARACTERISATION UNIT

After rotating the sample and taking many radiographs, it is possible to back-calculate the three dimensional internal structure. This can be viewed as a series of virtual tomographic sections.

FACILITIES

The system is based on an X Tek HMXT real time radiography unit with an AEA Tomohawk CT system. The conical X-Ray beam arrangement can achieve a resolution of 10µm.

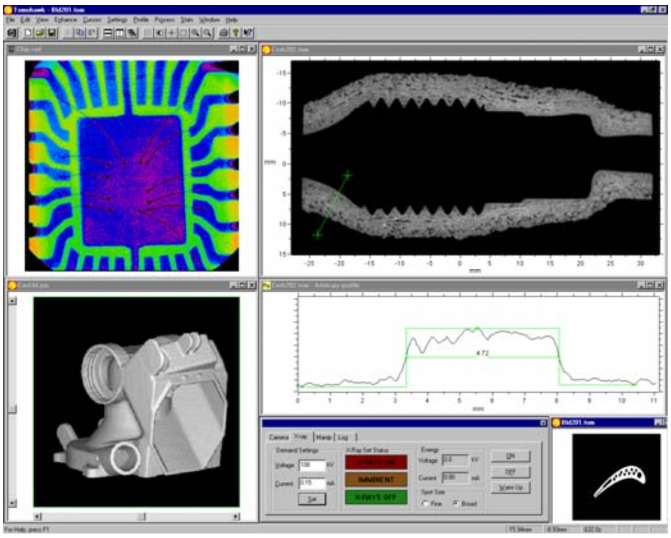
The HMXT has a 225 kV ultra focus (5µm spot size) X-ray tube which enables good images to be collected from samples with a thickness of:

20 mm in steel
100 mm in aluminium
170 mm in a carbon fibre type composites.

There is no real minimum sample size, good results have been obtained with samples as small as 1 mm in diameter. Maximum sample size is determined by X-ray absorption and magnification required.
Resolution: 10 µm can be achieved for small samples. For larger objects - around 100 mm in diameter - 300+ µm can be achieved.

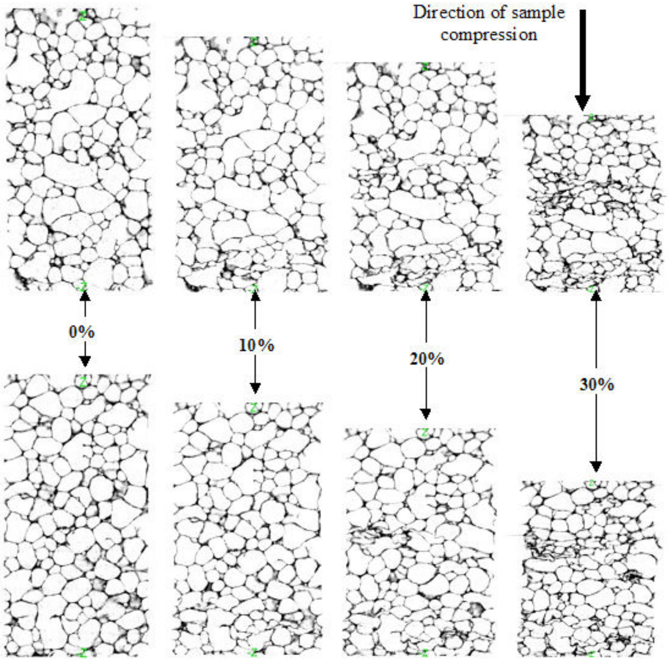
We also have access to a system with improved resolution of 1 - 6 µm, based on parallel beams, at ESRF (European Synchrotron Radiation Facility), Grenoble. This facility offers a field of view of ~1 mm, available at 1 µm resolution, but sample size is limited to a few mm.

Example AEA Tomohawk CT reconstructions:

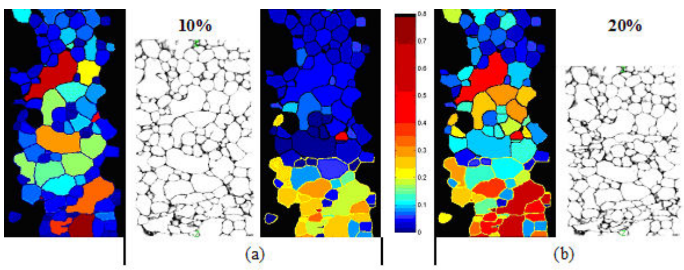


(Image courtesy of Dr S Burch, AEA Technology, Culham)

Case Study (1) – Compressive deformation of aluminium foam.

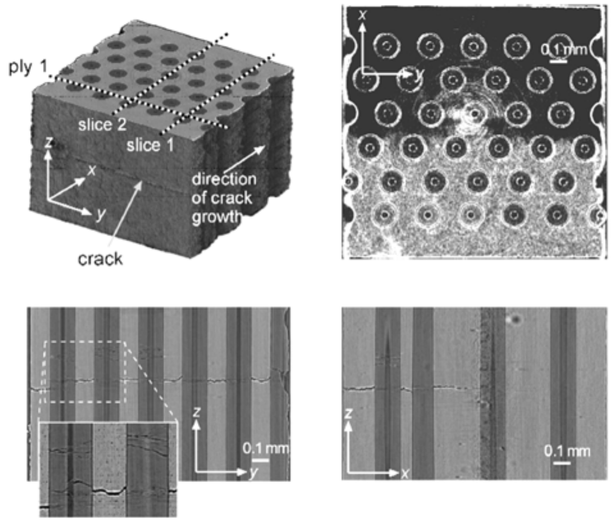


A sequence of slices through tomographic reconstructions of an aluminium foam sample as a function of compression, as indicated, reveal uniform localised deformation bands across the sample perpendicular to the direction of loading. This allows such a cellular structure to absorb a large amount of energy, useful for crash protection

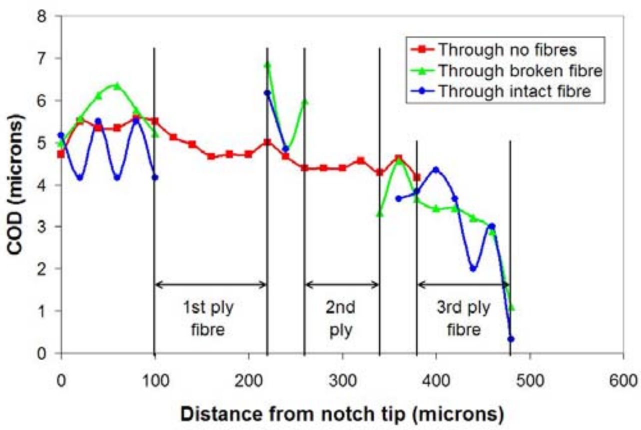


The individual cells in the tomographic dataset can be labelled in 3-D according to their size (volume, left). This can then be compared to slices labelled according to the strain experienced by each cell at 10% and 20% height reduction (red corresponds to a strain of 0.8 and blue zero). Thus a link between the position of the largest cells and the deformation bands is observed.

Case Study (2) – Fatigue cracking in a SiC-fibre reinforced Metal Matrix Composite.



3-D reconstruction, from which virtual 2-D slices have been extracted as indicated, of a multi-ply unidirectional SiC fibre reinforced Ti matrix composite. The extent of matrix cracking, the presence of cracked fibres (three in ply 1), and crack-bridging by the intact fibres are observed.



The tomographic data can be used to make crack opening displacement (COD) measurements from individual slices in order to analyse the crack bridging effect of the fibres. Intact fibres across the crack path are observed to shield the crack tip and decrease the effective stress intensity, leading to crack arrest and a lower COD.

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