



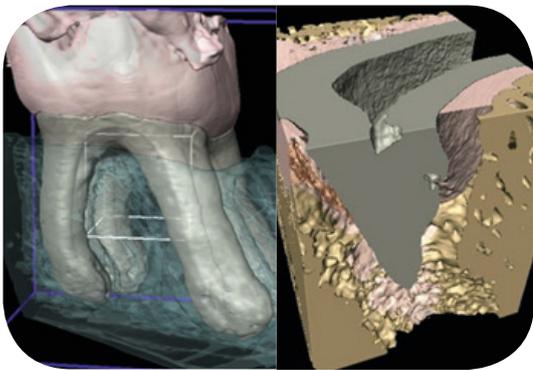
Using μ XCT/XRM in-situ tensile/compression testing stages - CT500

In-situ testing stages provide an immediate interpretation of how the properties of materials and composites change under different loading and temperature conditions. Deben have developed a range of tensile/compression and cooling sub-stages to work with the most common μ XCT & XRM systems.

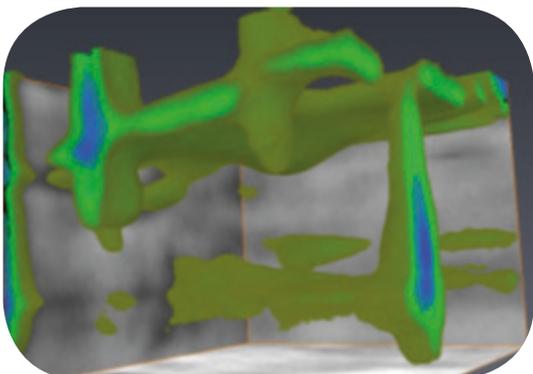
3D X-ray microscopy facilitates quantitative understanding of microstructure under both ambient and in situ environmental conditions. This enables imaging and tomography of microstructures as well as observation of micro- and nano-structural evolution under a variety of conditions.

In association with the major manufacturers of μ XCT systems including Zeiss, Nikon, GE and Bruker, Deben offers an integrated tensile testing solution for μ XCT applications. Tensile testing with μ XCT provides a clear visual interpretation of how the properties of materials change under different loading conditions. The compact design of these testing stages allow them to be used with the smallest high resolution micro CT systems providing a range of tensile, compression and torsion stages with forces up to 20kN and resolutions down to 25mN. Variable temperature options enable users to work from -20°C up to $+250^{\circ}\text{C}$. There are also options enabling work in-liquid and in an environmentally controlled chamber.

Many different materials may be studied using μ XCT & XRM. These range from teeth and bones to complex advanced composites. Deben stages may be found in laboratories worldwide. Here, we look at a range of practical applicators.



Micro X-ray CT images of animal teeth showing roots in bone



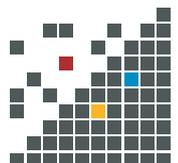
3D network of cracks in a fibre/matrix: The sample has been loaded from bottom to top of the image; the blue areas show where the fibres have been removed. Minor cracking is observed perpendicular to the load direction.

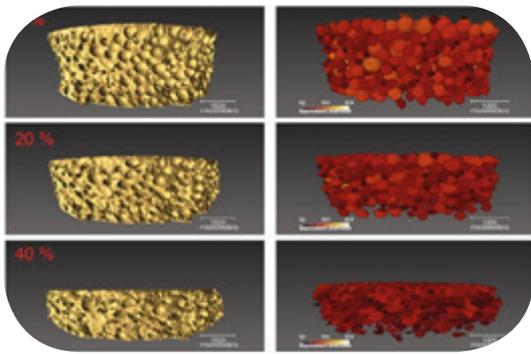
Bone:

Dr Sunita Ho's research team in the Division of Biomaterials and Bioengineering at the University of California San Francisco's School of Dentistry use a Deben CT500 tensile stage to visualize organs under loaded conditions. Scans obtained at no load and loaded conditions are used to evaluate mechanical strains in volumes of tissues. "The use of the Deben stage coupled to our x-ray microscope is optimum, enabling us to perform multiscale biomechanical analyses on organs, in that strains within volumes of tissues in intact organs are mapped. The ability to couple the loading device with a microscope is a key requirement for in-situ biomechanical testing and strain mapping."

Ceramics:

The compact size and easy to use software of the CT500 influenced Dr Brian Abbey of La Trobe University in Melbourne. Three-dimensional, in-situ stress/strain analysis has important applications in both materials science and biology. The group purchased the Deben CT500 tensile stage with a view to exploring the evolution of samples subjected to stress at micron length scales and in three-dimensions.





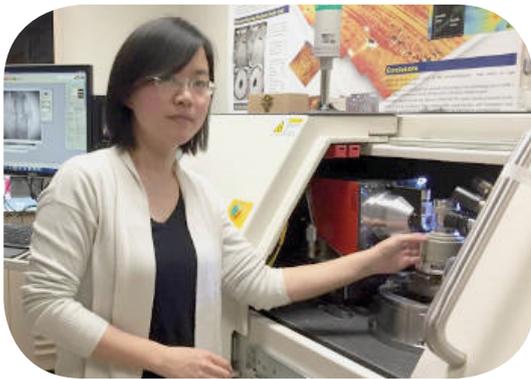
The images here show the effect of increasing compression on the voids within the foams (left) while the measurements on the right clearly show lateral strain. The sample's waist expands with increased compression while the voids are reduced in height and therefore volume.

Foams:

X-ray tomography provides excellent morphological and performance property information on polymeric foam systems. The Polymer and Coatings Group from Los Alamos National Laboratory have published data comparing different novel formulations of PDMS (poly(dimethylsiloxane)) foams. A Deben CT500 tension/compression cell was used in conjunction with a ZEISS Xradia μ XCT system to show the extent of damage when the foams were exposed to different levels of X-ray exposure.

The combination of the in situ mechanical data from the CT500 with that of the μ XCT has enabled clear differences between slightly different formulations to be observed. Further work on the effects of different filler materials on morphology and material resistance to cracking have shown similarly promising results to help tailor the performance of these foams and increasing their wear toughness.

(reference: Measure of morphological and performance properties in polymeric silicone foams by X-ray tomography: Patterson et al; J Mater Sci, DOI 10.1007/s10853-012-6965-2).



Post-Doctoral Fellow, Dr Jing Du, loads a bone sample into the Deben CT500 at the University of California – San Francisco

CT500 Summary:

- 500N Tensile & Compression testing stage for CT Tomography
- 360° clear line of sight through specimen
- Simple sample exchange mechanism
- High Strength ULTEM (polymer) support tube
- 3 and 4 point bending clamps

CT500 Versions:

- Room temperature only system
- Water bath option for compression while submerged in liquid.
- Load cell options: 50N, 200N, 500N

Contact Deben to discuss your μ XCT experimental requirements. Using their comprehensive MICROTTEST tensile stage control software with its wide range of control functions and a live display of load versus extension, stages are supplied with all required cabling and mounting adaptors for specific μ XCT systems.

Acknowledgements: Deben would like to thank the following users for their comments on the use of the stage and to allow reproduction of these applications images.

- Dr Sunita Ho, University of California – San Francisco: <http://bbct.ucsf.edu/>
- Dr Brian Abbey, La Trobe University: <http://www.imagingcoe.org/>
- Dr Brian Patterson, Los Alamos National Laboratory: <http://www.lanl.gov/expertise/profiles/view/brian-patterson>

