# *ON-THE-FLY X-RAY TOMOGRAPHY OF THE POROUS HYDROGEL SUBJECTED TO COMPRESSIVE LOADING*

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**Summary:** Presented work is aimed at demonstration of on-the-fly X-ray tomography for investigation of low attenuation porous hydrogel designed for bone tissue engineering applications. The patented tomography scanner (TORATOM, EP2835631) together with in-house developed micro-loading device was employed for experimental evaluation of the hydrogel deformation behaviour.

## 1. INTRODUCTION

In bone tissue engineering proper description of its deformation behaviour is one of the most important characteristics for assessment of biocompatibility and bone-integration characteristics of proposed structure intended to be used as a bone scaffold [1]. Newly synthesized hydrogel based bone scaffold in detail presented in [2] was subjected to compressive loading to obtain its deformation characteristic. The investigated material was synthesized as the porous spongy-like structure improved by the bioactive glass (BAG) nano-particles to comply the requirements for diffusion of nutrients and oxygen [3]. Low specific stiffness, which makes the sample susceptible to damage, and simultaneous low attenuation to X-rays makes both mechanical and imaging part of the deformation experiments challenging.

## 2. EXPERIMENTAL METHOD

Compression tests of the cylindrical samples with height $h = 9.0 \pm 0.1$ mm, diameter $d = 5.0 \pm 0.1$ mm and weight $m \approx 11$ mg were performed using custom designed uni-axial loading device. The device was designed for mechanical testing of materials during *in-situ* observation using X-rays, particularly computed micro-tomography. As the main frame of the device is made of transparent polymethyl methacrylate tube with 5 mm wall thickness the X-ray attenuation is is insignificant in comparison with attenuation of the irradiated sample. Loading platten displacement was set 1750 $\mu$m which corresponds to overall deformation $\approx 20\,\%$. Loading rate was set to $1\,\mu\text{m} \cdot \text{s}^{-1}$.

On-the-fly measurement under gradually increasing load avoided specimen relaxation presented during standard time-lapse imaging. The radiograms were acquired using the single photon counting detector in four modules (two-row/two-column) configuration. Every module is formed by single Timepix device with fast parallel readout and resolution $256 \times 256$ px at pixel size $55 \times 55\,\mu$m giving active area $\approx 2\,\text{cm}^2$. Maximum practical frame rate is 850 fps for 600 particles per frame resulting in approximately 0.5 million particles per second.

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During loading procedure 34 tomographies consisting of 400 radiograms per revolution were acquired. Based on the data volumetric datasets with voxel size 29.7 $\mu$m were reconstructed.

To evaluate displacements and strains in the deforming microstructure, the digital volume correlation (DVC) method was employed on the reconstructed tomographical images. The DVC method is generalization and extension of the two-dimensional digital image correlation, commonly used in image processing procedures, to three dimensions.

## 3. RESULTS

Possibilities of on-the-fly tomography for observation of porous low attenuation material was demonstrated. One tomography was acquired in $\approx 50$ s coresponding with less than 0.6 % sample deformation. Spatial deformation distribution was derived from 34 volumetric datasets. Deformed sample microstructure in perpendicular planes is depicted in Fig. 1.

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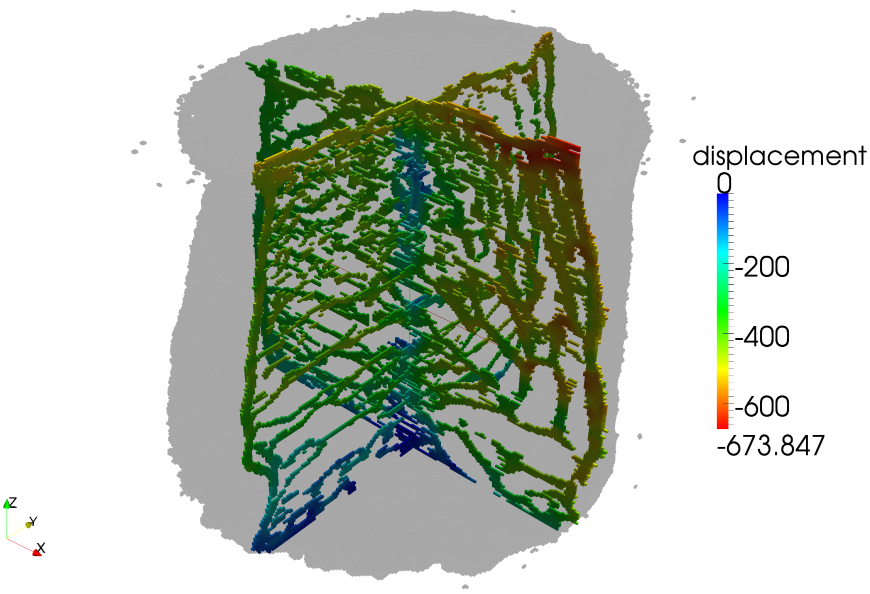


**Figure 1:** Displacements of sample microstructure obtained using DVC