ImageHeadstart .eu

Breakthrough Computer Vision Applications in the Micro World: Consortium of Research Organizations for Industry 4.0

Interreg
Austria-Czech Republic
European Regional Development Fund
EUROPEAN UNION

The project ImageHeadstart addresses the challenges of digital imaging in the fields of microscopy and tomography. Research on digital imaging techniques such as light microscopy and X-ray tomography at the partner institutions has reached a stage from which many practical applications can unfold. The main goal of the project is to help companies in the Austria-Czech Republic cross-border region to translate this knowledge into new applications and technologies.

The ImageHeadstart consortium will (1) integrate regional companies into the region's research structure, (2) bring together research institutions and regional companies, and (3) support research development in optomechanics, imaging, software development, and Industry 4.0.

To this end, the consortium will (1) organize regular information workshops, (2) create a system to register for bilateral and multilateral consultations, and (3) publish a newsletter on the consortium's technical progress.

Jihočeská univerzita
v Českých Budějovicích
University of South Bohemia
in České Budějovice

ÚTAM AV ČR, v. v. i., Centrum excelence Telč

Donau-Universität Krems
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ImageHeadstart news no. 3

INTRODUCTORY MESSAGE

In the last two years, we have experienced a number of changes that have affected both individuals and institutions and companies. Despite the fact that many activities slowed down and administrative regulations reduced or even prevented meeting of people, research and innovation activities continued, after we transferred our actions more into the online space. However, these changes have confirmed the importance of technology and the need for innovation for companies that want to stay competitive in a changing environment. In the ImageHeadstart project, we are trying to support these activities by offering a range of knowledge and inventions, specifically also in the field of X-ray tomography, which is covered in this Newsletter.

Michal Vopálenský, Laboratory of X-RAY Tomography, ITAM

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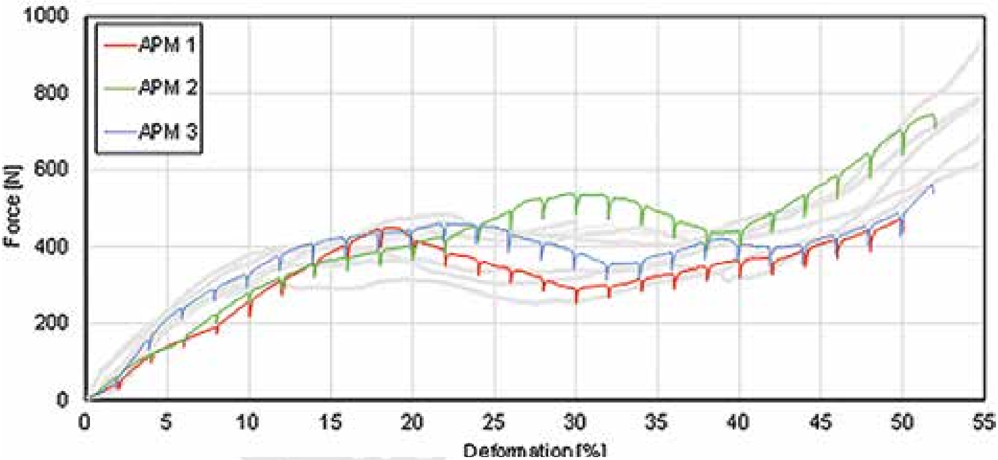
MICRO-COMPUTED TOMOGRAPHY AND IN-SITU COMPRESSIVE TESTING OF ADVANCED PORE MORPHOLOGY (APM) FOAM ELEMENTS

Demonstration of time-lapse X-ray tomography (4D XCT) for investigation of porous samples with complex microstructure designed for material engineering applications. The ITAM design and engineered tomography scanner together micro-loading device was employed for experimental evaluation of the APM deformation behaviour.

Advanced pore morphology (APM) foam elements are almost spherical foam elements with a solid outer shell and a porous internal structure mainly used in applications with compressive loading. To determine how the deformation of the internal structure and its changes during compression are related to its mechanical response, in-situ time-resolved X-ray microcomputed tomography experiments were performed. Simultaneously applying mechanical loading and radiographical imaging enabled new insights into the deformation behaviour of the APM foam samples when the mechanical response was correlated with the internal deformation of the samples. It was found that the highest stiffness of the APM elements is reached before the appearance of the first shear band, which was followed by stiffness decrease up to a point of self-contact at the beginning of the densification region.

Visualisation of a deformed APM sphere - reconstructed 3D image captured at 0 %, 25 %, and 50 % of overall compressive strain.

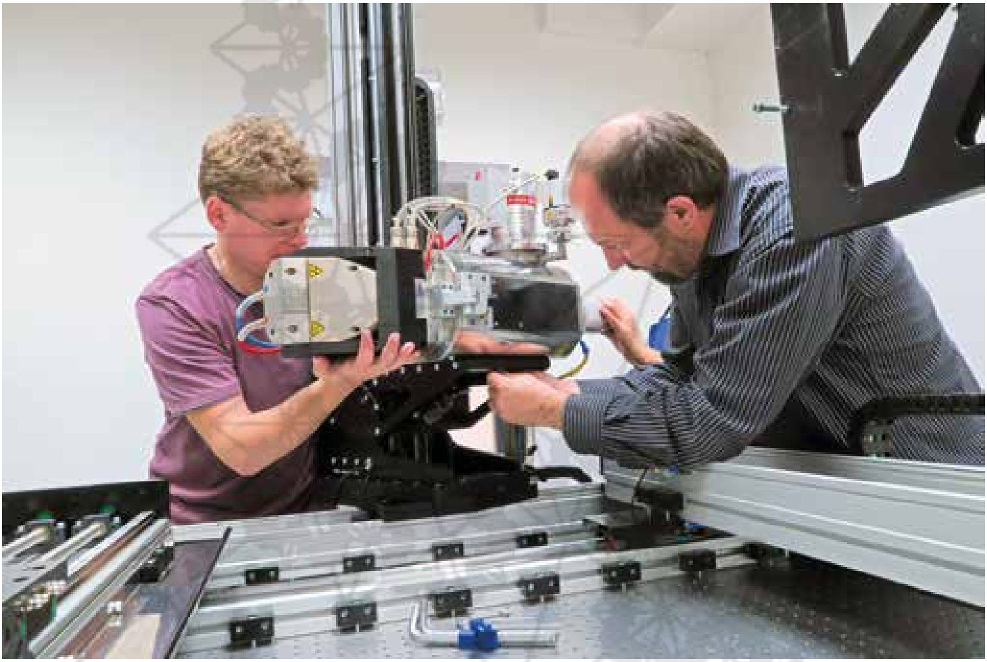


Loading curves of the preliminary tests (light-grey colour) and the three samples subjected to the time-lapse XCT imaging.

IMPROVEMENTS TO THE TORATOM TOMOGRAPH IN THE TELČ CENTER WILL SIMPLIFY TOMOGRAPHY OF TALL OBJECTS

New X-ray source manipulators, developed at the Department of Biomechanics, were installed on the TORATOM tomograph in the X-ray tomography laboratory in Telč. The TORATOM tomograph is unique, among other things, in that its geometry is adjustable over a wide range. This makes it possible to significantly change the resolution of the tomography as well as to create enough space for the insertion of relatively large objects, which is useful, for example, in the X-ray investigation of paintings.

Until recently, a major limitation was the insufficiently long and robust linear manipulator of both X-ray sources – the stroke was less than 200 mm. However, this problem was solved by installing new manipulators with a stroke of almost 1000 mm, called ToraLift by their designer Tomáš Fíla from the Department of Biomechanics of ITAM CAS. With this improvement, it is now much easier to perform scans of flat objects and create tomography of tall objects. The first tests of the so-called spiral or helical tomography were also already performed. Helical tomography further simplifies the study of tall objects by eliminating the need to stack multiple virtual objects created as individual tomograms at different heights into a single final model.



Installation of the ToraLift manipulator onto the Toratom tomograph.

One of the ToraLift manipulators.

Acquisition software for operating laboratory X-RAY tomography setup

Custom acquisition software tailored for the in-house designed X-ray tomography setup was developed.

High resolution computed tomography is a complex experimental procedure. It requires high-precision positioning, X-ray tube control, detector adaptation, image data read out, etc. To operate the in-house developed experimental X-ray setup, custom control software with all the necessary functionality was developed. It provides acquiring series of projections, which are later used for CT reconstruction, as well as acquiring correction data, such as dark image, flood image, map of bad pixels, setting of exposure time, number of exposures, projections averaging, live view with histogram view included, etc. The main concept of the acquisition software is to be modular and straightforwardly adapted to various detectors and other hardware due to the specific needs of particular experimental measurements, including imaging of quasi-static and dynamic loading phenomena or imaging of low attenuation biological material.

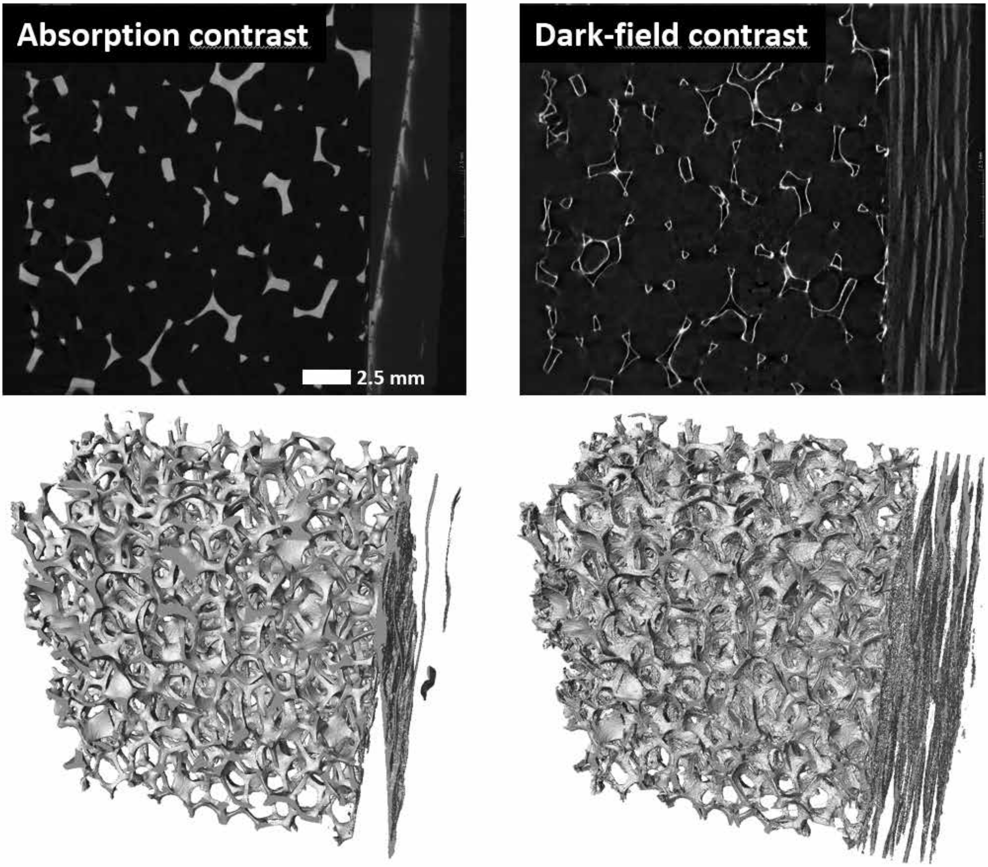
X-ray tomography setup inside the bunker.

The acquisition software of the X-ray setup.

FEATURE EXTRACTION IN CFRP COMPOSITES USING ADVANCED MICROCOMPUTED TOMOGRAPHY

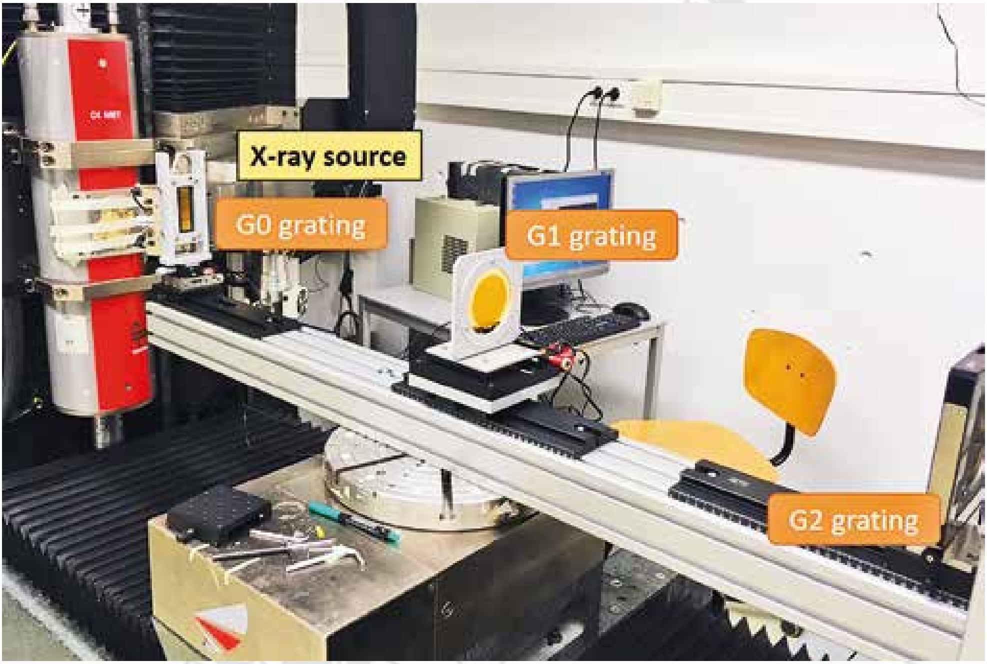
The University of Applied Sciences Upper Austria houses a Talbot-Lau grating interferometer (TLGI) X-ray computed tomography (XCT) system (Sky-Scan1294, Bruker). The phase contrast XCT scanner uses a microfocus X-ray source, an 11 MP detector and three specially designed X-ray gratings to simultaneously extract information about absorption, refraction, and scattering. In contrast to conventional XCT, TLGI-XCT provides three complementary characteristics in a single scan of the specimen: a) the absorption contrast (AC), b) the differential phase contrast (DPC), and c) the dark-field contrast (DFC). Using two different TLGI systems in the ImageHeadstart project, we visualize various samples including CFRP laminates that are used in lightweight applications, e.g. in combination with aluminium foam cores. The application of such multi-material lightweight sandwich panel structures can increase the structural efficiency and impact energy absorption. However, using conventional XCT it is not possible to visualize fine structures, e.g. single struts and walls in the foam, and the weaving pattern in the CFRP laminate at the same time.

Due to the fact that DFC delivers morphological information in the sub-pixel regime depending on the local scattering power, dark field imaging delivers information that may otherwise be inaccessible using conventional XCT. Using a Talbot-Lau XCT we show that dark field images yield a high contrast and a strong signal at interfaces, in particular for the foam microstructure and the carbon fiber rovings in the CFRP panel. The specimen shown below was scanned at isometric voxel size of 22.8 µm.

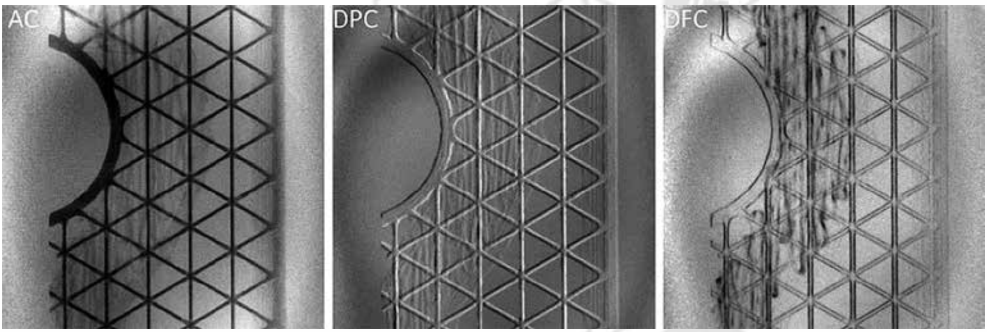


Multi-modal imaging of a carbon fiber face sheets with an aluminium foam core scanned usinga Skyscan 1294 phase contrast CT system (voxel size: 22.8 µm).

In order to be able to perform TLGI inspections on larger samples, a grating interferometer from Mcroworks (Germany) was installed in the RayScan 250E XCT scanner at the Upper Austrian University of Applied Sciences. The setup consists of three gratings that are mounted on high resolution piezo stages for nanopositioning. This setup allows for a quick installation and removal of the entire interferometer system that can be used to obtain radiographies including absorption, differential phase, and dark-field contrast.



TalInt grating interferometer setup installed into the RayScan 250E system at the University of Applied Sciences Upper Austria. From left to right, X-ray source, G0, G1 and G2 are visible.



TLGI radiographies of a CFRP sample investigated at the TalInt grating interferometer setup. Carbon fiber rovings are clearly visible in the DFC image.

Description of company
National Tissue and Cell Center https://natic.cz/

Workplace Brno

The National Tissue and Cell Center is involved in the development and preparation of medicinal products from human tissues and cells for highly personalized and effective treatment in cases where patients cannot be treated with conventional drugs or other conventional methods, or where human tissue and cell therapy is more patient or more efficient.

natic.cz

The company's goal is to use human cells and tissues to enable all people to increase their quality of life and improve their health, or even save their lives in very serious diseases. The company is involved in the development of a number of medicinal products for applications in the field of orthopedics, traumatology, hematology, immunology, regenerative medicine and the treatment of ischemic diseases. Other products are aimed at the treatment of skin defects and wound healing. Cooperation with research organizations on a regional, national and transnational scale is an essential part of the company's continuous development. With its facilities and the range of services offered, it is one of the leading and top workplaces of its kind in Europe.

One of the fundamental factors for the clinical use of tissues is the temporal stability of their biomechanical properties. The company is involved in the development of procedures for stability studies using radiographic methods for monitoring the deformation response to load. The 4D microCT method and digital correlation of volumes make it possible to obtain the total field of displacement of the microstructure of the examined tissue.

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