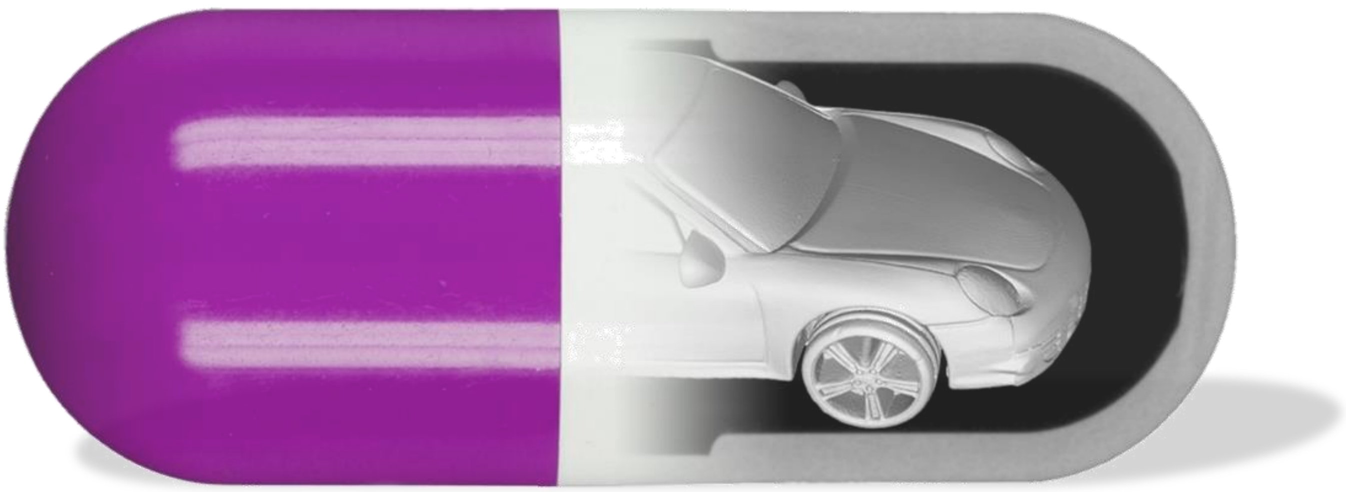
Focus Analytics

NEWSLETTER OF RD&I ANALYTICS April 2024

High-Resolution Computed Tomography – Insight into smallest details



WHETHER YOU NEED TO DEVELOP FUNCTIONALIZED COMPONENTS OR TO OPTIMIZE PRODUCTION PROCESS IMAGING TECHNIQUES - METROLOGICAL EXAMINATION METHODS ARE AN IMPORTANT PART OF EFFICIENT MATERIAL AND METHOD DEVELOPMENT TODAY.

WE OFFER COMPLETE SOLUTIONS FROM ONE SOURCE

- **Competitive analyses**
- **Solutions for product and process optimization**
- **Investigations of composite material systems**
- **Complaint analyses**
- **Patent litigation support**

While most imaging techniques can only image the surface, the high-resolution computed tomography (µ-CT) also enables a closer view into the content or rather the interior of the objects. In this way, multilayer or multicomponent systems, for example, can be examined quickly and precisely in a non-destructive manner - without any preparation effort. At the same time, the objects can be visualized in detail as a three-dimensional model. With µ-CT, we are able, for example, to investigate the cause of failure of complex components or examine the process quality of printed components. To obtain the highest resolution, we focus on differences in the material density of the sample. Therefore, this method is particularly suitable for the analyses of material combinations, like multilayer and filler/matrix systems.

SAMPLE EXAMINATION "FROM A SAND GRAIN TO A BASKETBALL"

Materials:
Plastics, glasses, ceramics, nature-based materials, thin metal layers

Sample dimensions:
Up to 280 mm in diameter and 700 mm of height

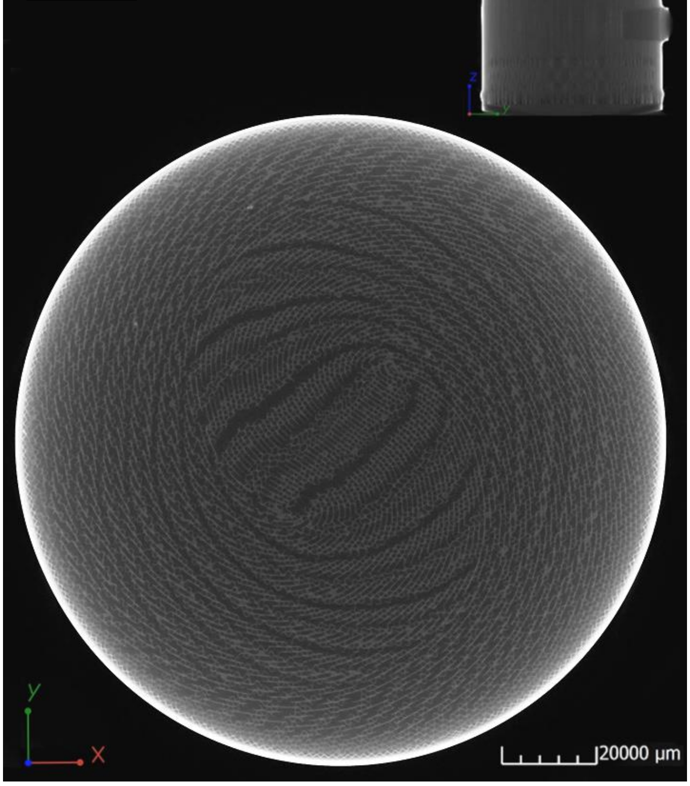
Sample weight: max. 17 kg

Worth knowing:

The smaller the object, the higher the resolution (Voxel-size from 3 to 50 µm)

For interfacial investigations, density differences between the materials should be at least 0,3 g/cm^3 (even better > 0,5 g/cm^3)

Fig. 1



Catalyst monolith made of structural ceramics. Simultaneous display of the virtual intersection plane in the object (small image above, blue line) and the inner structure of the object at that position (large image) is

ADVANTAGES OF µ-CT

- Non-destructive examination
- A fully reconstructed 3D-dataset in common formats is obtained
- Individual evaluation of the obtained data, no additional measurements necessary
- Virtual cross-sectional images from arbitrarily selectable angles are possible
- Selective imaging of e.g. particles of a particular density (by hiding of the environment matrix)
- Comparative component testing, by means of true-to-scale overlay with other digital images
- Provision of image and video material of the examination is possible
- Free data viewing software (3D) for facile evaluation and presentation are available

INVESTIGATION OF FUNCTIONALITIES

Dimensions and geometries:

Determination of any distances, dimensions and volumes

Functional components:

Electronic components, sensors, actuators, vents

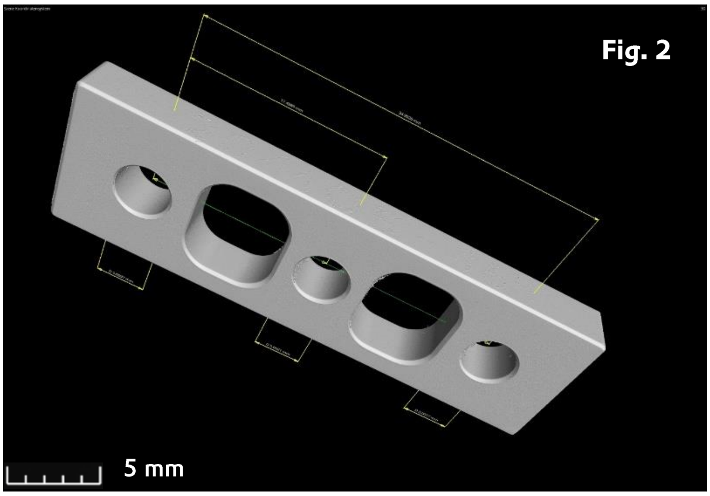
Clarification of the causes of damage:

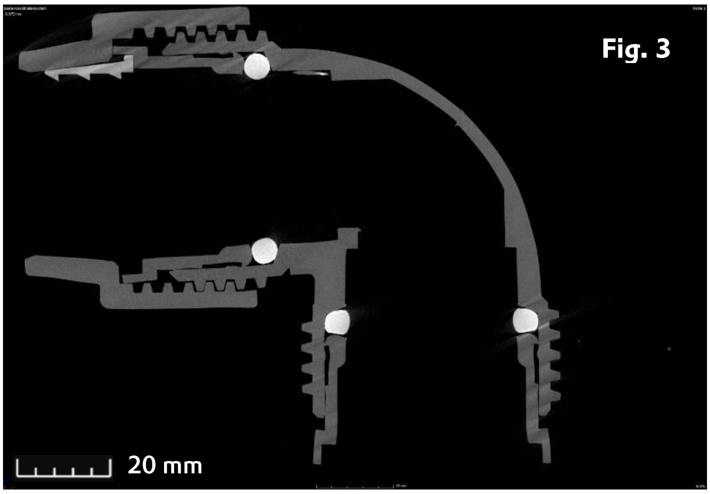
fractures, microcracks, dislocations, bubbles, blowholes, gaps, delamination

Multi-component systems:

Reinforced components, organic sheet products, battery modules, membranes

EXAMPLE: Functional Components





High-resolution computed tomography can also be used to examine components where purely optical methods are no longer sufficient: Geometrically complex components with **undercuts or radii** can be **precisely measured** and then displayed as a **3D model**, e.g. for **simulations** or as a comparison with the according CAx data (Fig. 2). Process-related shrinkage or deformations can be precisely recorded in this way and subsequently corrected in the technical process.

It is also possible to check or optimize the **position of overmoulded components**, such as **metal reinforcement elements** inserted into plastic or **sealing elements made of elastomers** (Fig.3, bright areas show the position of sealing rings and their form-fit in cross-section).

Molded or functional parts produced in different **3D printing processes** can be evaluated in terms of **print quality**, **positive fit** and **complex geometry**.

This method can also be used to **non-invasively test the accuracy** and tightness of plug-in systems in the application and to examine for weak points or particularly stressed areas, signs of wear after load tests or complaints.

Especially after component failures, µ-CT is the method of choice, as material destruction by sample preparation is avoided and the obtained images are therefore reliable evidence.

VISUALIZATION OF STRUCTURES

Cell Structures:
Cell structure, interfaces sintering effects, homogeneity of cells and cell walls

Material Changes:
After mechanical, thermal or chemical stress

Material Properties:
Permeability and resistance of the material towards liquid media

Series of investigations:
Using the same sample, depending on the time e.g. after external exposure

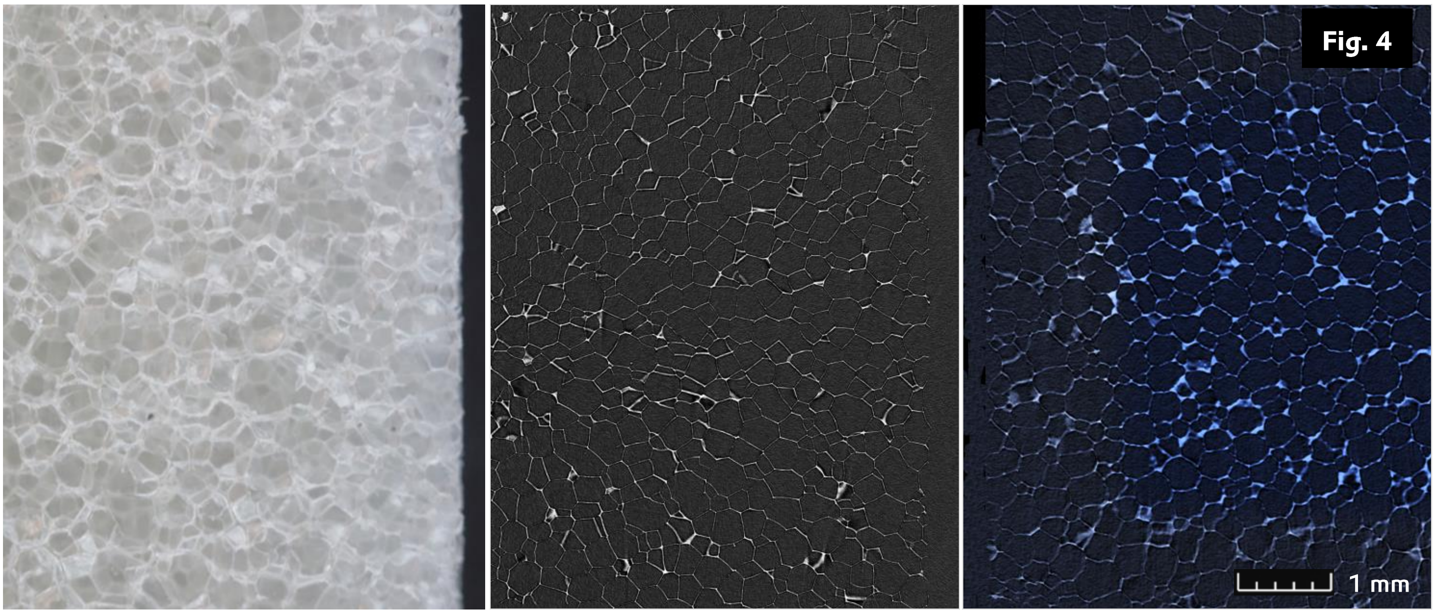
In addition to the examination of e.g. the condition of safety-relevant semi-rigid foams before and after mechanical stress (such as an impact), it is also possible to answer questions that could not be answered by mechanically prepared cross-sections of the sample - e.g. the **behavior** of a foam **towards liquids**.

The µ-CT image of a foam (light microscope image, Fig. 4, left) shows empty cells and narrow cell walls under standard conditions (Fig. 4, middle). After water storage, the cell walls are significantly thickened (Fig. 4, right, highlighted in blue), but the cells do not contain any fluid. The µ-CT images show that the foam swells and stores water but does not allow water to pass through directly.

With the help of CT technology, **comparative series** can be produced in which, for example, the gradient of the degree of swelling of a stored foam sample is recorded **at arbitrary time intervals** and thus the re-drying behavior of the material is determined.

Furthermore, CT technology can be used to develop the material regarding the cell size and characteristics of cell walls. In this way, the **properties of a material** can be quickly understood and then modified in a targeted manner.

EXAMPLE: Rigid foam



INVESTIGATION OF PROCESSES

Process optimization:
In terms of setting parameters and geometry

Packing density und distribution:
Of particles and fillers

Plastic molded parts:
Compact, filled, reinforced, foamed

Metal foiling and coatings
Gas or vapor barriers, sealing layers

Structural components made of ceramic
Plastic reinforcement, etc.

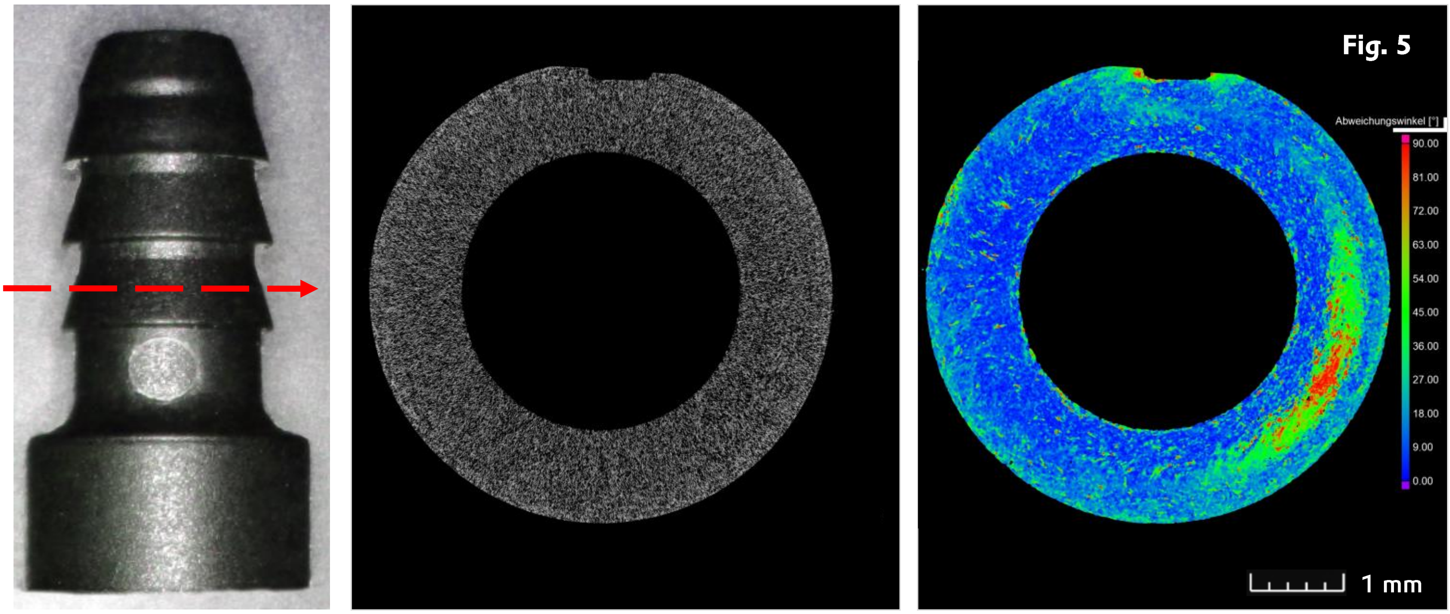
3D printed components:
Implants, technical components

With the help of µ-CT, prefabricated components made of, for example, fiberglass-filled plastic can be examined non-destructively and comprehensively. The method enables **any number of virtual sections** (red dashed arrow, Fig. 5, left) to be made through the component **from different angles**, e.g. to examine the **distribution** (Fig. 5, center) and **orientation** of the glass fibers (Fig. 5, right) in the material.

The associated software can even be used to display the **deviation** of the glass fibers in the component from the calculated **ideal angle** for the application of force (Fig. 5, right): The **ideal alignment of the glass fibers** in the plastic (blue) indicates high stability, a large deviation from the ideal angle (red) indicates **weak points in the component**. This illustration shows precisely where the injection mould or the sprue **position** needs to be **adjusted**, thus facilitating the process optimization.

The data generated with µ-CT can be used for a **filling simulation**, which can be used to optimize the **production/injection moulding process** and thus ultimately increase the subsequent **stability** and service life **of the component**.

EXAMPLE: Injection-moulded plastic parts



INVESTIGATION OF FUNCTIONS

Analyses of coatings:
Thickness, homogeneity, completeness

Material bond of layers:
Dislocations, delamination, inclusions, phase boundaries

Evaluation of the material and coating quality:
In general, at critical points, on the in- and outside

In situ visualization of mechanical stress:
Prestressed components (tensile or bending load)

Time series during storage
Changes after (climate) storage

The µ-CT provides insights that can hardly be obtained in any other way, but are of great importance: Whether a gelatine-based active ingredient capsule (Fig. 5, left) actually **seals tightly** and later releases the active ingredient at exactly the right time or how **homogeneously** the active ingredient mixture is **distributed** at which **filling level** (Fig. 6, center: longitudinal and cross sections) can hardly be determined in such a **precise way** by any other method.

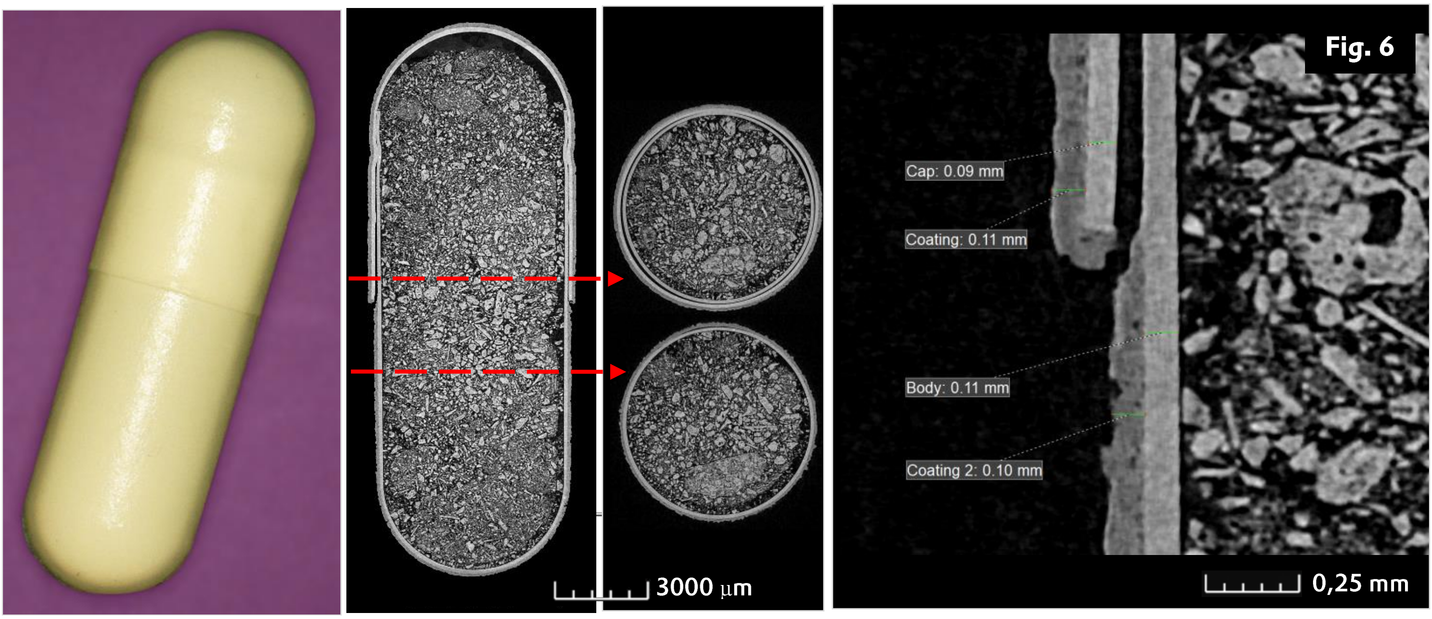
In addition to the tightness and **accuracy of fit** of the multilayer capsule halves, the images can also be used to determine the **coating quality and thickness** of the acid-resistant protective layer around the entire capsule, particularly in the sealing area (Fig. 5 right).

The **adhesion of the coating** to the capsule and its quality itself can also be examined using the high resolution of the µ-CT. Also bubbles or delamination can be detected.

Even after storage in different climate zones (simulation by climate storage), changes in the same sample can be compared.

In this way, the µ-CT delivers **reliable results** quickly and unambiguously and makes a major contribution to the **development of a safe product.**

EXAMPLE: Pharmaceutical preparations (multi-component/layer systems)



Do you have any questions?

We are glad to advise you on the most suitable methods for your questions and coordinate all the necessary steps, from the sample arriving to its examination and the final analytical report.

Our devices as well as the evaluation methods follow the current state of the art.

We stay in personal contact with you and support you in evaluating the results, if you like.

The final summary includes images and, if desired, videos for further use. Your questions will be answered to the point.

We are at your disposal for a concluding presentation and discussion of the results.

Get in touch with us!

We are happy to create a customized concept or offer for you.

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https://analytik.evonik.de

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