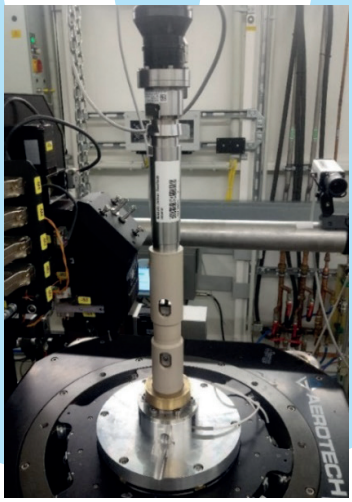
Microtomography -
Investigation of fiber reinforced polymers for high-pressure hydrogen applications

The **Leobersdorfer Maschinenfabrik GmbH** is a leading OEM for reciprocating compressors located in Leobersdorf, Austria. Green hydrogen technology is the key to a future sustainable climate neutral society. To replace CO_2 emitting energy carriers, existing networks must be utilized, and fossil fuels substituted by high-pressure hydrogen. Novel power-to-gas concepts use electrolysis-technology to convert electrical energy from renewable sources into hydrogen. Energy densities and flow rates competitive to batteries or natural gas, require hydrogen storage and transportation at high pressures > 500 bar.

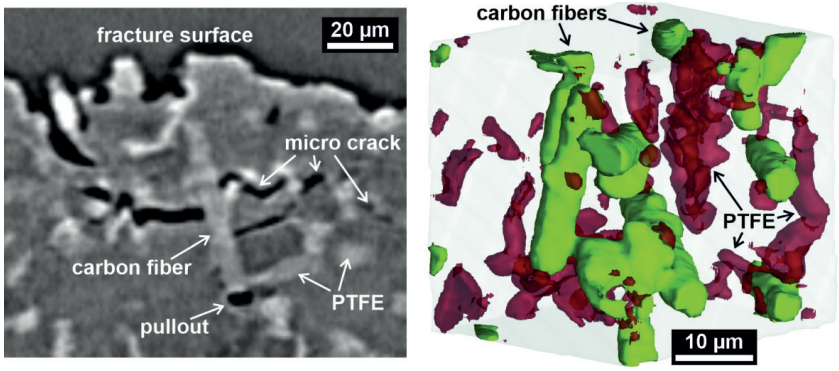


Custom setup for in-situ tensile testing of fiber reinforced polymers at the synchrotron radiation based x-ray computed microtomography station operated by Hereon.

Therefore, advanced polymer piston ring solutions are being developed in cooperation with **MOCOM Compounds GmbH & Co. KG** (Hamburg, Germany) and the **University of Applied Sciences Upper Austria** (Wels, Austria) to deliver uncontaminated high-pressure hydrogen in non-lubricated operation. Thermo-mechanical loads and friction put high demands on high-performance polymer sealing solutions, subject to development.

Investigation of thermomechanical properties and microstructural effects on deformation mechanisms were performed in PPS matrix composites with synchrotron based *in-situ* microtomography. Researchers from LMF and the University of Applied Sciences Upper Austria designed a custom setup, which enables tensile testing of fiber reinforced polymers during high-resolution tomography experiments. The measurements were performed at the synchrotron beamline IBL/P05, operated by the Helmholtz-Zentrum Hereon at DESY (Deutsches Elektronen-Synchrotron) in Hamburg, Germany.

During these experiments, the scientists got new insights in failure initiation and propagation in the composites' microstructures under simulated operation conditions. Fiber-reinforced polymers and their optimal compositions could be identified, suitable for piston and packing ring solutions in high-pressure hydrogen compressors.



Synchrotron radiation-based x-ray computed microtomography at P05, with 15 keV photon energy and a resolution of 2.7 µm. Carbon fiber reinforced composites with PTFE content were analyzed by 3D phase segmentation using the excellent absorption contrast sensitivity of low energy synchrotron light. Crack propagation near fibers during tensile testing (micro cracking and fiber pullout) on the left, as well as phase distributions in 3D with carbon fibers (green) and PTFE inclusions (red) on the right, gave new insights in polymers' viscoelastic deformation behavior under simulated operation conditions.

„Deformation mechanisms in carbon fiber reinforced polymers could be investigated utilizing the unique properties of highly brilliant synchrotron radiation."

Michael Schöbel
Leobersdorfer Maschinenfabrik GmbH

References
A. Pöllinger et al. Polymer (2023) 126500
A. Pöllinger et al. Polymers (2024) 16030412

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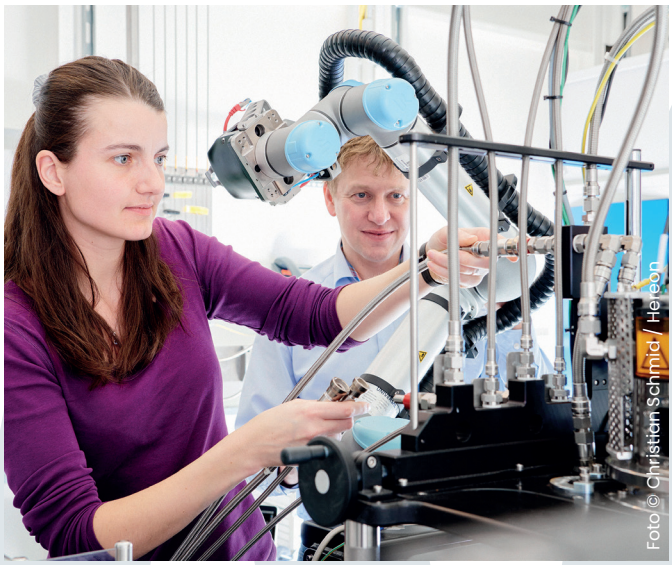

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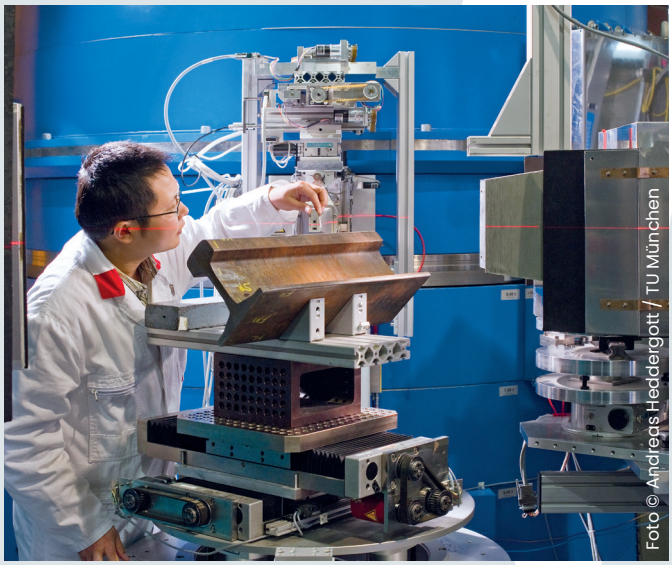

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Contact:
Helmholtz-Zentrum Hereon
Dr. Marc Thiry
Industrial Relations Officer
Phone +49 (0)40 8998-6914
industry@gems.hereon.de

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German Engineering Materials Science Centre
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