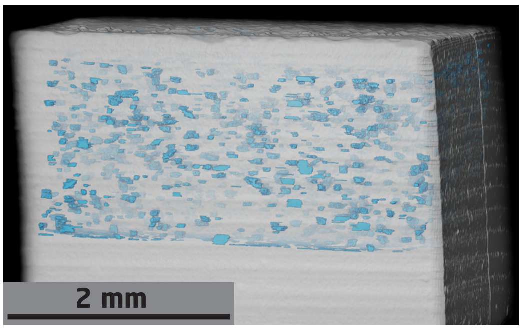
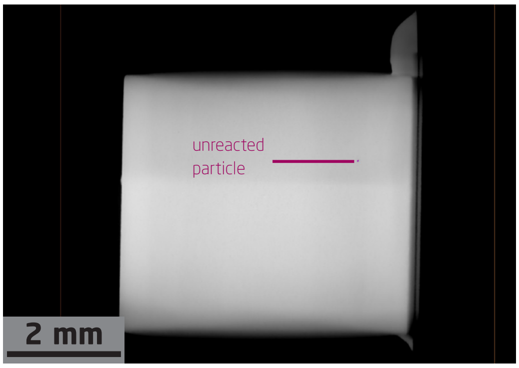
Characterizing materials to harvest waste energy

The company TEGnology develops modules to convert waste heat into electrical energy. By doing that, some of the otherwise wasted energy can be re-used, e.g. for monitoring applications in automotive systems. So far, most of the materials for such purposes have either been limited to lower temperatures, based on environmentally critical materials, or very expensive, but TEGnology developed new materials which can overcome these challenges. In order to characterize the newly developed materials with modern X-ray based methods, TEGnology has engaged with Aarhus University and DTU to perform both X-ray diffraction measurements and X-ray micro Computed Tomography (CT) scans via a collaboration within the LINX project.

Sample on a sample holder for X-ray CT .



3D rendering of the unreacted particles of the fresh material (blue) within the full volume (grey).



Ortho slice through the long-term high-temperature treated material showing only one unreacted particle.

Challenge

TEGnolgy is interested in both the general appearance of the produced materials, and in how long-term use affects the homogeneity of the produced samples. Therefore, two different studies using X-ray micro Computed Tomography (CT) were set up: a) on freshly produced materials and on materials which had been in use for more than 1000 hours, and b) on a first and second generation material, which differ in chemical composition. The challenge regarding data acquisition and subsequent quantitative analysis was that the materials absorb X-rays heavily, which requires high-energy X-rays to penetrate the samples sufficiently. In order to obtain a satisfying image quality, test measurements with different in-house X-ray micro CT systems were carried out at the 3D Imaging Center at DTU and the best parameters for the CT scans were evaluated.

Collaboration

Through the collaboration between TEGnology and the 3D Imaging Center at DTU, the material was characterized using micro X-ray Computed Tomography, while X-ray diffraction measurements were carried out in collaboration with Aarhus University. This collaboration was part of the LINX project, in which researchers at leading Danish universities collaborate with scientists in industry to solve industry-relevant problems using advanced neutron and X-ray techniques.

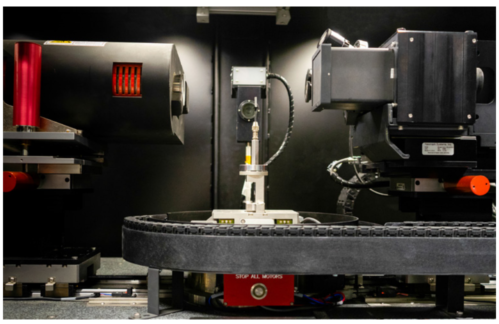
Results

In order to penetrate the materials, X-ray micro CT was carried out using a Nikon XT H225 industrial scanner at 190 kV and 220 kv respectively, and the full samples were analyzed with a spatial resolution of about 20 µm. It was seen that the freshly produced materials contained particles of higher density, which can be considered to be a result of incomplete synthesis. The same material, after having been exposed to long-term high-temperature use, showed hardly any unreacted particles any more. This finding shows not only a long-term stability since no pores or other defects occured after long-term high-temperature exposure, but it even reveals a homogeneizing effect of the high-temperature application due to the significant reduction of the amount of unreacted particles. These findings are shown in the pictures on the left.

Imaging Industry Portal

The Imaging Industry Portal is a part of the 3D Imaging Center at DTU and assists companies in using and implementing 3D Imaging in research, development and production. The portal offers research-based 3D Imaging services and provides companies with the latest equipment and the most advanced knowledge within 3D Imaging and data analysis. The Imaging Industry Portal works as a gateway to ESS and MAX IV, as well as other large scale facilities.

www.imaging.dtu.dk/english/Industry-Portal



DTU 3D Imaging Center