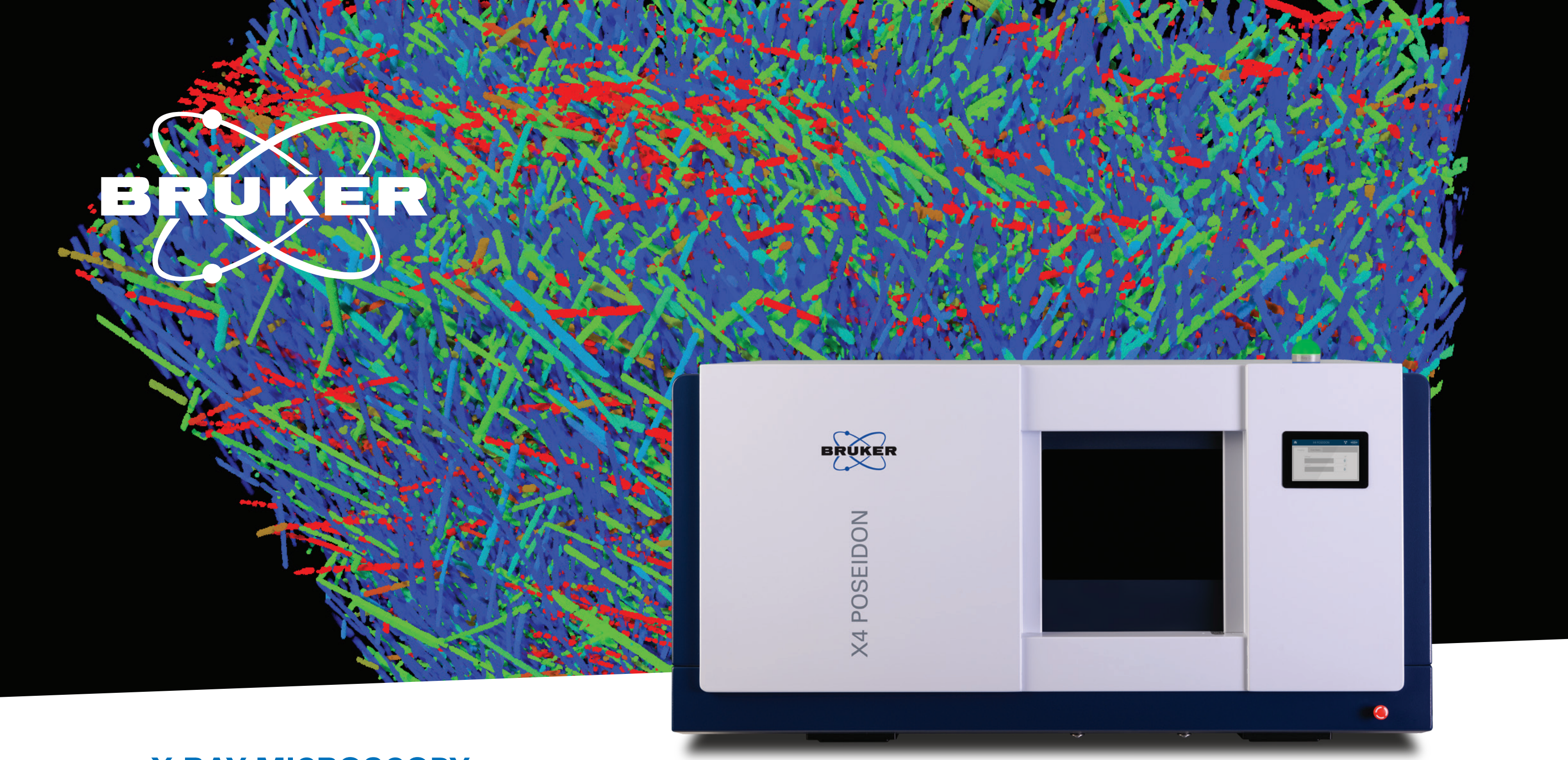

X-RAY MICROSCOPY

X4 POSEIDON – Carbon Fiber Reinforced Plastics (CFRP)

Application Report 6

Carbon fiber reinforced plastic (CFRP) is attracting significant attention as a key material for next-generation technologies and industries due to its combination of high tensile strength, rigidity, and lightweight properties.

The mechanical performance of CFRP is strongly influenced by factors such as the orientation and density of carbon fibers, as well as the presence of internal voids and defects. Gaining a detailed understanding of these internal structures is essential for accurately evaluating the strength of CFRP and optimizing its design.

Analyzing the internal structure of CFRP requires the ability to resolve gaps as small as a few microns. Traditional destructive methods, which involve cutting samples, risk altering the structure and compromise the accuracy of the analysis. To address these challenges, high-resolution, non-destructive imaging technologies are essential for obtaining detailed and reliable insights.

High-resolution 3D X-Ray Microscopy (XRM) offers a powerful solution by enabling the non-destructive visualization of CFRP's internal structure in three dimensions. This advanced technique makes it possible to observe the orientation and density of carbon fibers, detect internal voids and defects, and perform quantitative analysis of gaps between fibers with exceptional clarity and precision.

The X4 POSEIDON is a compact desktop XRM system that offers high-resolution imaging capabilities while fitting into most laboratory spaces. Its versatility and precision make it an ideal solution for investigating the detailed internal structures of CFRP without damaging the sample.

The X4 POSEIDON microCT imaging workstation is a 3D imaging core facility on your desktop. The following settings were used for this study:

- 16 Mpixel sCMOS X-ray camera
- 80 kV, 25 µA
- Scan duration: 16 hours 12 min
- Voxel resolution: 600 nm

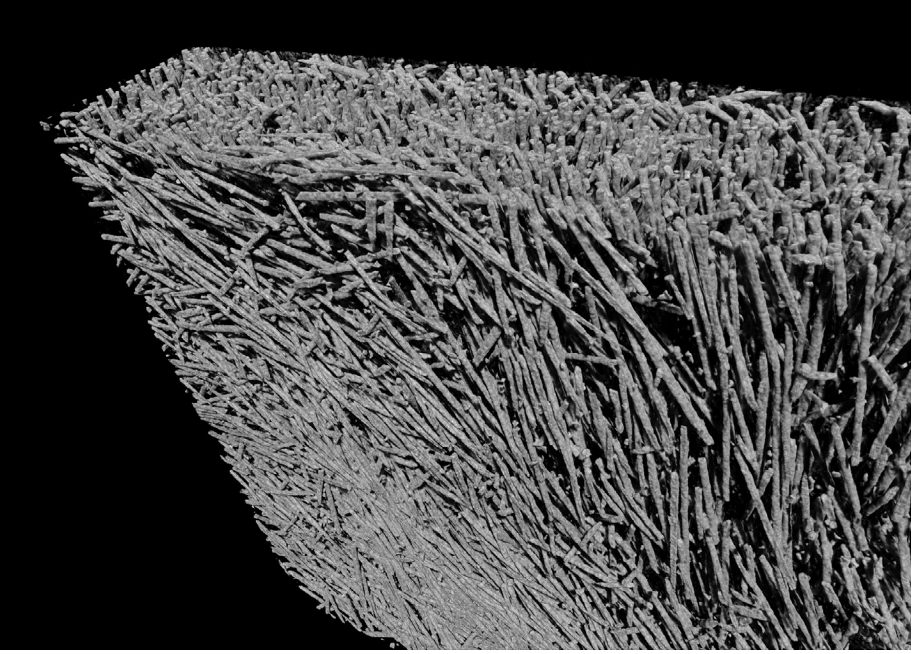

Figure 1
3D volume rendering of the carbon fibers with the polymer matrix virtually removed.

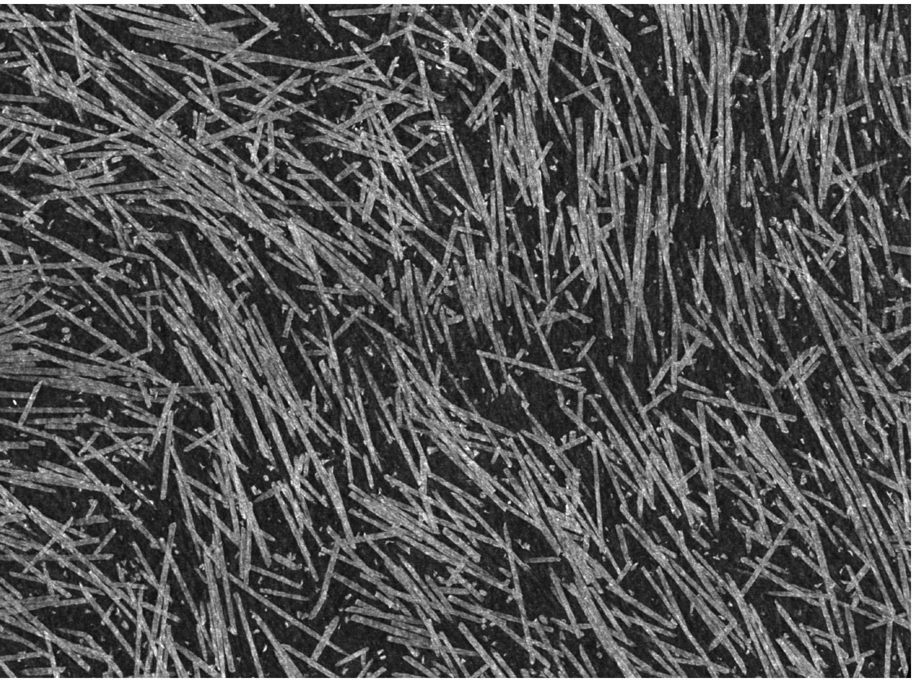

Figure 2
Maximum Intensity Projection for observation of fiber orientation.

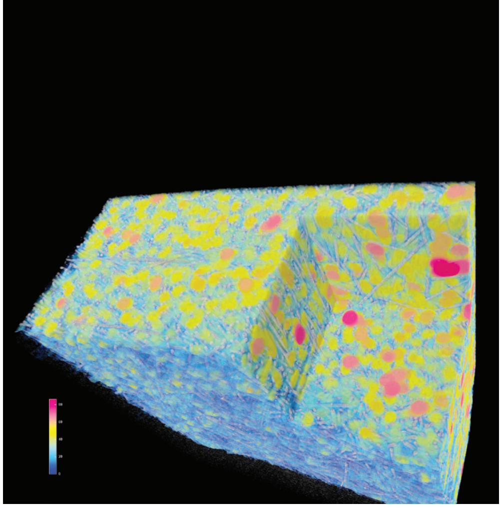

Figure 3
Distribution analysis of fiber distance.

The orientation of the carbon fibers in the CFRP can be clearly observed through the 3D volume rendered image (Figure 1). This visualization allows for a comprehensive overview of the fiber alignment throughout the sample.

Another intuitive way to understand the fiber orientation and packing density is through the maximum intensity projection (MIP) image (Figure 2). This 2D view displays the voxel with the highest intensity from the 3D data.

For a quantitative evaluation, a structure separation analysis can be performed to understand the spacing between fibers using CT Analyzer (CTAn). The resulting color-coded 3D image (Figure 3), highlights the distance between individual fibers, offering insights into the fiber density distribution across the sample. This analysis is crucial for evaluating the mechanical properties of CFRP, as fiber density directly influences the material's strength and performance.

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