CFRP Void and Fiber Analysis by X-ray CT

About the sample: CFRP (Carbon Fiber Reinforced Polymer/Plastic)

Carbon fiber reinforced polymers or plastics are often called CFRP. CFRPs contain carbon fibers as a reinforcing agent and binding material, which is normally a thermoset resin such as epoxy and polyester. CFRPs are strong and light and used where high strength-weight ratio and rigidity are required such as aerospace, automotive, and sports equipment industries. Voids and cracks can compromise the strength of CFRP. Characteristics of the carbon fibers such as the orientation, length, or packing density affect the performance of CFRP. X-ray CT (computed tomography) is non-destructive and has sufficient resolution to resolve these characteristics and analyze them quantitatively.

Watch the video about the sample: CFRP (Carbon Fiber Reinforced Polymer/Plastic)

Analysis procedure

In this example, a CFRP piece was scanned using a submicron-resolution CT scanner, nano3DX.

The CT image was segmented into fibers, matrix, and voids using the machine learning segmentation technique. The void size and fiber orientation were analyzed.

1. CT scan

About a millimeter size piece of CFRP was scanned to produce the 3D grayscale CT image. The gray level in CT data (left) represents the relative density. The cross-section shows the 7.5 microns diameter carbon fibers (light gray), matrix (mid-tone gray), and voids (dark gray).
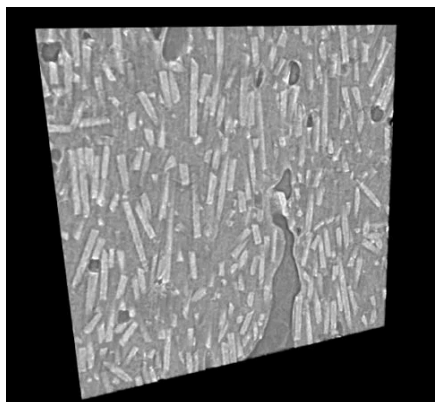
2. Image segmentation

The CT image was segmented into fibers (yellow), matrix (blue), and voids (red) using the machine learning segmentation technique. Individual voids and fibers were separated and indexed by using the watershed transformation technique to analyzed the individual void size and fiber orientation.
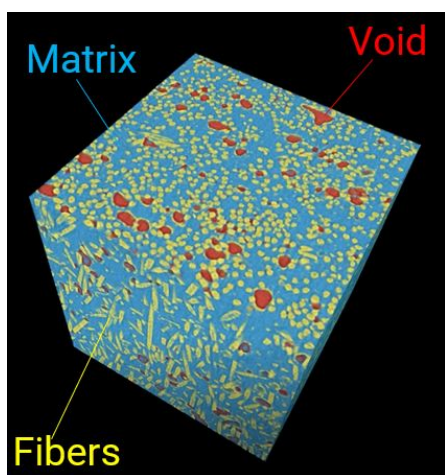

3. Void size and fiber orientation analysis

Most voids were under 1e4 cubic microns (purple), but several large voids up to 3.1e5 cubic microns (red) were also observed. An example of 3.7e4 cubic microns void (blue) is shown in the figure.
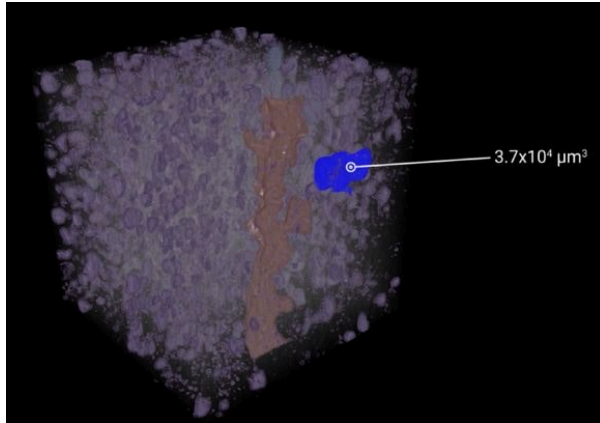
The carbon fiber orientation was analyzed and color coded in the 3D rendered view. In the rainbow spectrum, green represents the fibers oriented in the vertical direction, while blue and red represent the horizontally oriented fibers. Overall the vertical direction was recognized as the preferred direction in this CFRP sample.
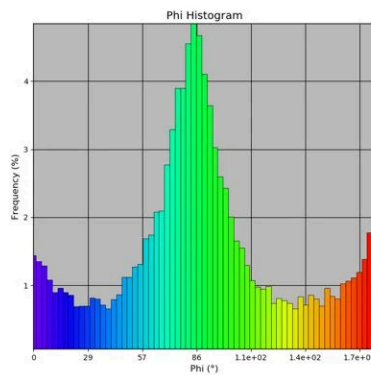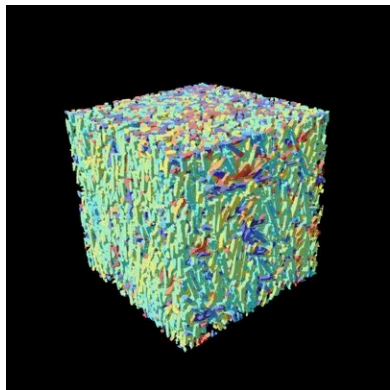
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