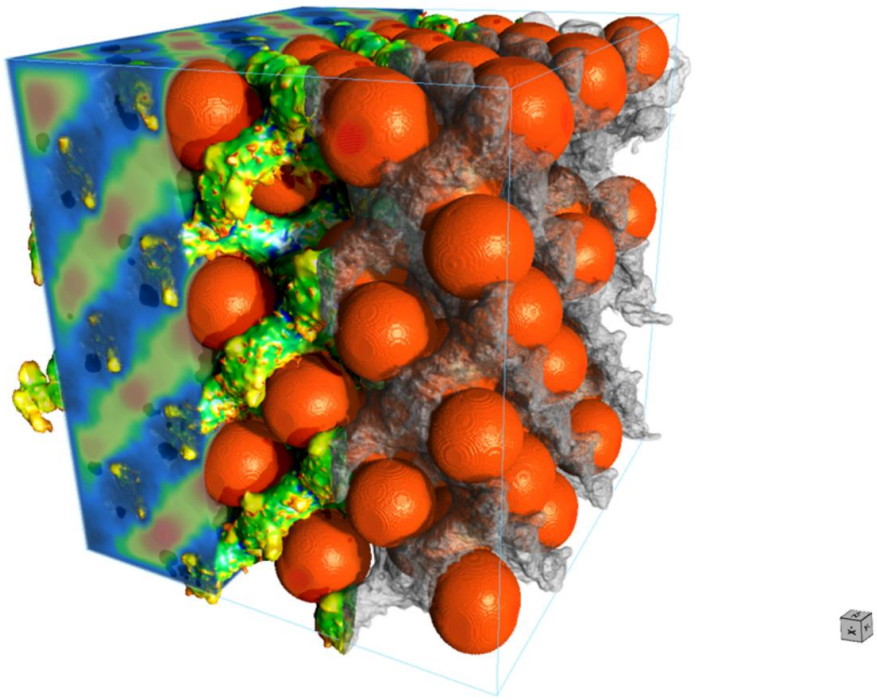
Application Note



Additively Manufactured Lattice Structure Characterization using Dragonfly 3D World

What you will learn in this application note:

- How to analyze a lattice structure
- Get void fraction
- Strut thickness analysis
- Microporosity analysis
- Macro pore space analysis

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Introduction

In this application note, a full detailed analysis of an additively manufactured lattice structure is demonstrated. From basic measurements of material/air volume fractions to advanced measurements such as strut thickness, microporosity in the material, maximal spheres of macroporosity, statistical analysis and more.

Requirements

A high-resolution micro-CT scan of a lattice structure is needed. The lattice structure in this work was manufactured by metal additive manufacturing in Ti6Al4V and total length is 6 mm across. Dragonfly 3D World is needed for the analysis.

Typical outputs:

- Volumes and volume fraction of material vs air space
- Strut thickness analysis
- Microporosity / void analysis inside the material
- Macroporosity analysis using volume thickness mapping
- Statistical analysis and CSV outputs possible

How does it work?

The first step is to (optionally) rotate the data to be square in the 3 orthogonal views using the translate/rotate tool. The next step is segmenting the material vs air fractions. Since we are interested in the lattice and not the external air, a box shape is useful to limit the volumetric measurements to a selected volume as shown in Figure 1. The segmentation is done with Otsu thresholding of the material, and using a “fill inner areas” function to include microporosity into the material fraction (yellow). A duplicate ROI is created and inverted, combined with box-shape masking of the ROIs. ROI volumes in this case are 52.95 mm^3 for the material and 166.32 mm^3 for the air fraction, making the material relative density equal to 31.84 %.

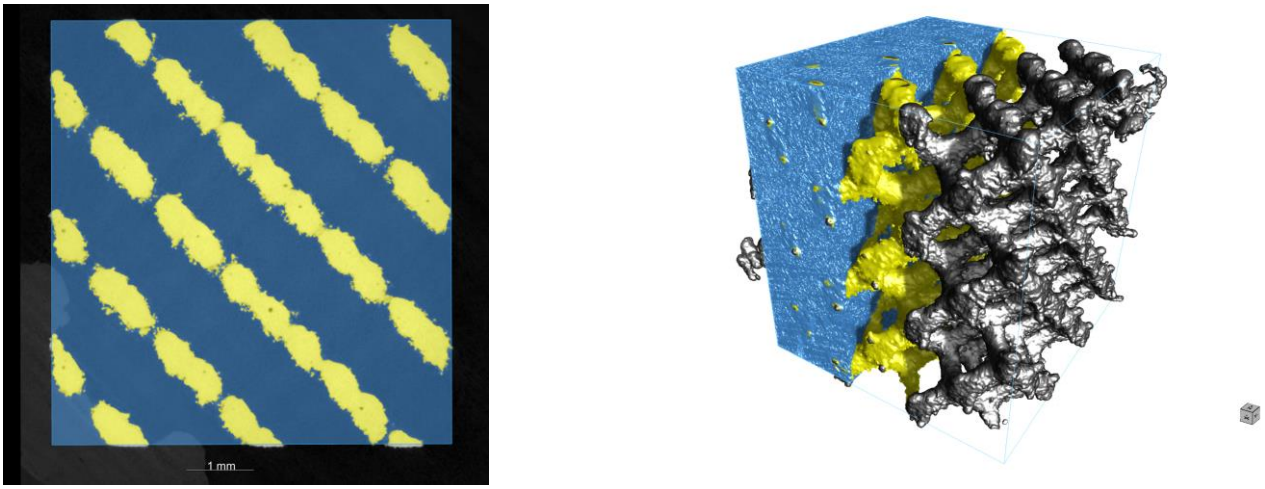


Figure 1: Segmentation of air and material phases in a lattice sample of 6 mm across. From the segmentation, volumes and volume fractions can be easily extracted. The 3D image shows a cropped view for visualization purposes.

The next step is to analyze the microporosity in the material struts, shown in Figure 2. For this segmentation, the automated porosity segmentation – advanced Otsu method was used. The resulting segmentation shows the largest pores are 0.1 mm in diameter and the total volume fraction is 0.1 % compared to the total material volume.

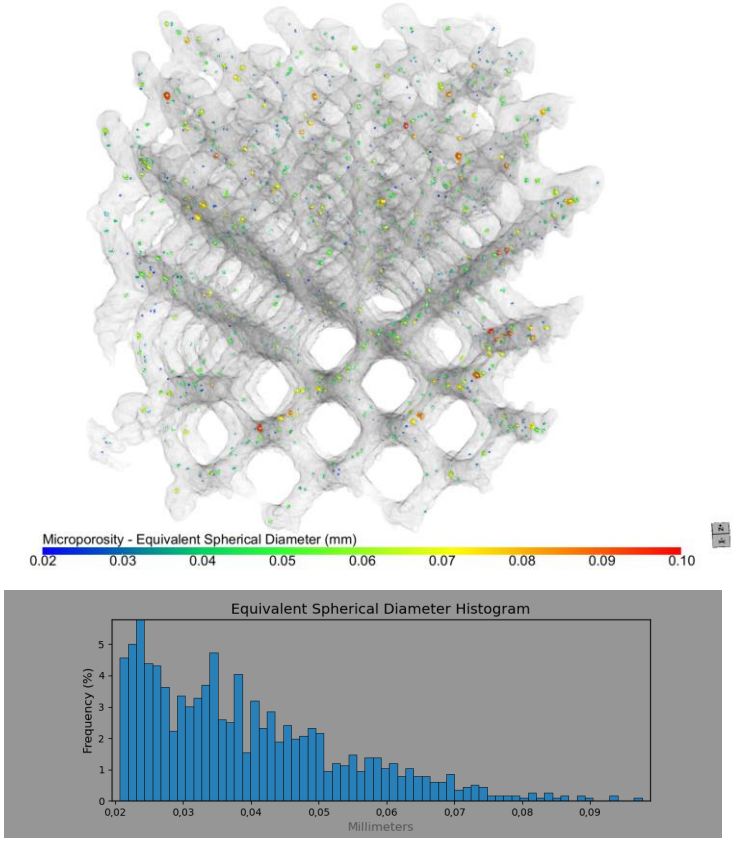


Figure 2: Microporosity analysis – color coding by diameter shows largest pores are 0.1 mm. The pore size distribution shows the nr of pores vs size.

Something also of interest is to understand the strut thickness distribution, here we employ the mesh thickness function to get a color-coded thickness analysis and thickness distribution, as shown in Figure 3. The distribution shows a peak at 0.4 mm that corresponds to the mean thickness of the struts. The joints between struts contribute to a peak at a larger value as well.

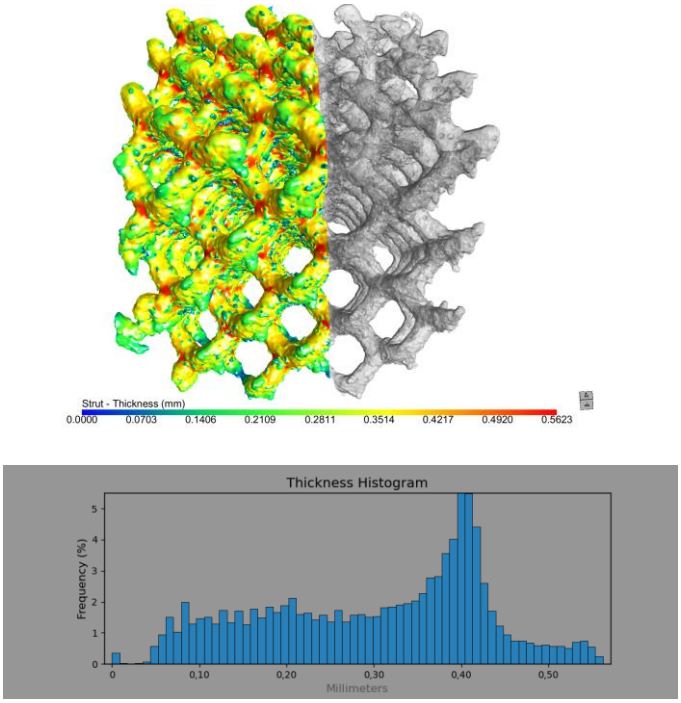
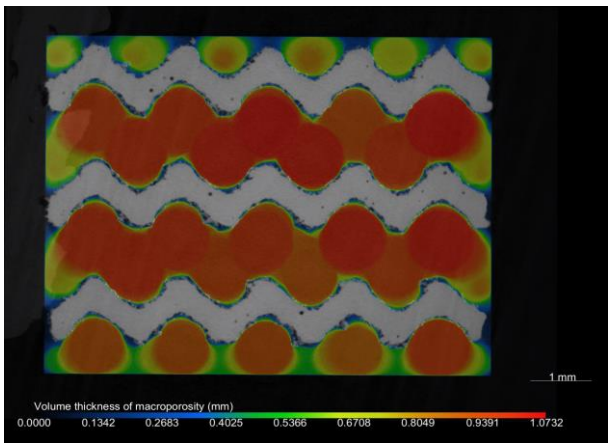
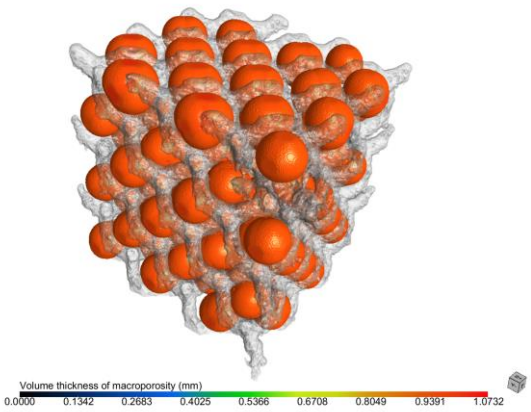


Figure 3: Mesh thickness analysis applied to a lattice, showing the local strut thickness and its statistical distribution.

In some applications you might want to analyze the macropore sizes – the pore spaces between the struts. For this you can use Dragonfly's volume thickness mapping tool. As shown in Figure 4, this function allows to color code the maximum diameters of spheres fitting to the spaces in each location and gives a statistical analysis showing that most of the macropores are 1 mm in diameter in this case.





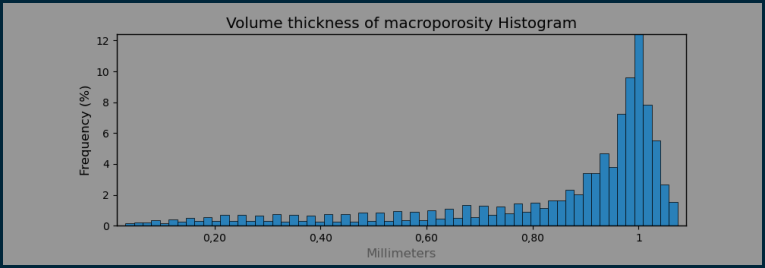


Figure 4: Volume thickness mapping analysis of pore spaces between the lattice struts, revealing that most of the pore spaces are 1 mm in diameter.

Summary

- Additively manufactured lattices and porous materials can be fully characterized
- Volumes and volume fractions are calculated from segmentation using a box tool
- Microporosity in struts are quantified
- Strut thickness is quantified
- Pore spaces are analyzed
- All above allows statistical analysis and CSV export, in addition to 3D images and videos

The benefits

A detailed characterization allows to compare different manufacturing processes and to check for combination of needs for the manufactured product. The resulting measurements can be used for quality control and for process improvement.

For a video workflow demonstration of the above case:
https://www.youtube.com/watch?v=WJ38wmYDVEk

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