# Modeling the Effect of Porosity on the Elastic Properties of Synthetic Graphite Using CT Scans and the Finite Element Method

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## Abstract

Predicting physical properties and performance of carbon and graphite materials based on the microstructure of the finished material continues to be a very challenging endeavor, like it has for many decades. However, recent advancements in three-dimensional measurement techniques using X-ray computed tomography (CT) combined with analysis breakthroughs using Simpleware's ScanIP™ software are beginning to answer this question in ways never seen before and represent the cutting edge of carbon and graphite materials science characterization.

This paper discusses the process and workflow for measuring and analyzing the pore structure of graphite combining advanced CT image technology with Simpleware's ScanIP™ software technology.

In summary, a stack of scanned CT images, as shown in Figure 1, are imported into ScanIP and converted into a solid model, as shown in Figure 2. After the images are converted into a solid model, the images are further enhanced into a higher quality, analysis-ready mesh using Simpleware's +FE Module. The enhanced mesh is now ready to be directly imported into the COMSOL Multiphysics® simulation environment.

Using COMSOL Multiphysics, tensile stress-strain responses for three synthetic graphite samples of varying maximum grain size are simulated as shown in Figure 4. The results of the simulation found the presence of pores reduced the solid modulus by 18% to 62% and the solid Poisson's ratio by 1% to 8%. Although in this case the pores reduced the solid modulus and Poisson's ratio, other properties, for example fracture resistance, may or may not be affected.

As a result of this new process, we were able to simulate results one would achieve through physical experiments and now have a successful workflow to support future modeling efforts. The exact relationship between porosity and all properties is not well known and remains an area of ongoing research.

# Figures used in the abstract

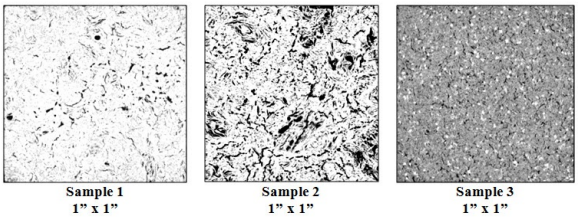


**Figure 1**: Figure 1. Examples of CT scan tiff image showing pores (black) and solid (white/grey).

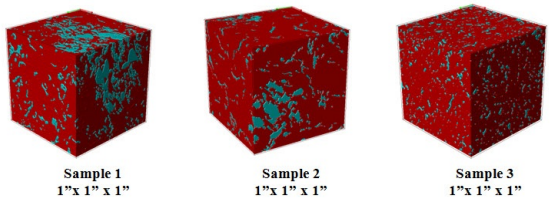


**Figure 2**: Figure 2. Examples of 3D CT reconstructions. Red is solid and blue are pores.

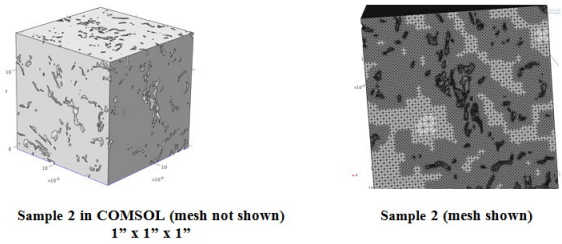


**Figure 3**: Figure 3. COMSOL model of Sample 2.

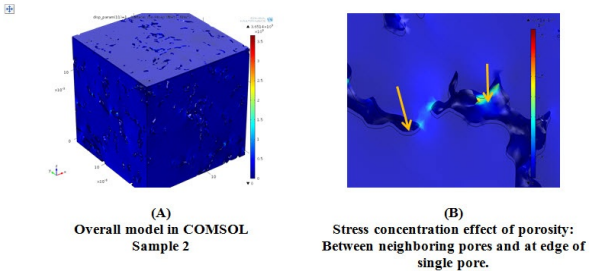


**Figure 4**: Figure 4. Stress concentration effect of porosity.