

## A digital characterization of CFRP composite material for multi-scale foundation modeling

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### Abstract

Multi-scale modeling methods that use a representative volume element (RVE) for computational procedures are based on various techniques. These methods typically use a cross-sectional micrograph as a starting point and convert the same to computer-aided design (CAD) files or use an algorithm-based virtual reconstruction of the RVE in a CFRP UD laminate. This study lays down an algorithm (based on a geometric series function) to recommend the right size of RVE that yields a mean and constant variance of any property of interest at the lamina level. This resultant output is referred to herein as the continuum length scale (CLS) of the RVE, below which any property's lack of convergence in variance during analysis may render its output prone to inaccuracies at the lamina level. A second part of this study is to use this CLS for the novel development of various meso-level parameters on a 2D micrograph cross section of a UD cured laminate to provide quantifiable, digitized output that also provides correlation with the fiber prepreg processing parameters. These novel meso-level parameters of a 2D cross section are largely based on the observed deviations of the Kirchoff's plate theory assumptions as applied in classical lamination theory (CLT) in a real-world CFRP composite laminate. This algorithm is implemented in MATLAB using the Image Processing Toolbox. The easy-to-use algorithm is applied on a representative number of cross-sectional micrographs of a UD laminate to generate a statistically meaningful result. When this algorithm is applied on CFRP laminates produced from different prepreg processes, a clear meso-level parameter distinction is seen. The use of this method may enable a comprehensive digitized foundation for Machine Learning (ML) and Artificial Intelligence (AI) algorithms' implementation of digital twins in various CFRP application analyses.

### References:

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