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Analysis of Material design Space and Ligament Microstructure of Carbon Foam for Optimal Stiffness and Multifunctionality

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ABSTRACT

The optimization of the ligament orthotropic microstructure of carbon foam is desirable to tailor the foam bulk response. Two carbon foam models are developed at two different scale levels to correlate salient foam ligament microstructural characteristics with the bulk response. The microscopic model focused on the effect of microstructural material orthotropy to foam ligament response, and the macroscopic model is to thoroughly analyze the effect of the ligament deformation behavior to the bulk response. The macroscopic model contains tetrakaidecahedral ligament configuration containing 36 ligaments in the model RVE, based on the homogenized ligament properties obtained from the microscopic model. The macroscopic model provides a powerful closed form expression for predicting foam bulk modulus correlating that with the ligament microstructural characteristics. This closed form expression for the bulk modulus is also provides a basis of analyzing the carbon microstructure of the ligaments to assess multifunctionality of carbon foam. Analysis indicates that the presence of planar graphine sheets in the ligament microstructure, preferred for superior thermal and electrical conductivity, does not provide adequate bending stiffness and shear rigidity. In this context, we will analyze the zig-zag configuration of the graphine sheets in the ligament microstructure to optimize multifunctional (thermal, electrical, and mechanical) bulk response of carbon foam.