Overview of the Effort
A NASA Ames Research Center (ARC) effort, under the Entry Systems Modeling (ESM) project, aims at developing microtomography (micro-CT) experiments and simulations for studying materials used in hypersonic entry systems. X-ray micro-tomography allows for non-destructive 3D imaging of a materials micro-structure at the sub-micron scale, providing fiber-scale representations of porous thermal protection systems (TPS) materials. The technique has also allowed for In-situ experiments that can resolve response phenomena under realistic environmental conditions such as high temperature, mechanical loads, and oxidizing atmospheres. Simulation tools have been developed at the NASA Ames Research Center to determine material properties and material response from the high-fidelity tomographic representations of the porous materials with the goal of informing macroscopic TPS response models and guiding future TPS design.

Micro-tomography of Ablative TPS Materials
A wide range of materials are imaged from the sub-micron to centimeter scale. The high quality tomography reveals 3D features of complex microstructures, woven architectures, and decomposition phenomena.

Micro-tomography based simulations
The Porous Materials Analysis (PuMA) software has been developed to determine a materials effective properties and response based on its microstructure (either tomographic or computationally generated). The GUI-based PuMA platform allows tomography segmentation and 3D image rendering based on a marching cube discretization of the tomography iso-surfaces.

Effective Material Properties
Simulation tools have been developed to compute the porosity, specific surface area, thermal conductivity, electrical conductivity, diffusivity, tortuosity, and representative elementary volume of a material based on its micro-structure.

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References