X-ray micro-tomography of ablative heat shield materials

Francesco Panerai[a,*], Joseph Ferguson[b], Arnaud Borner[c], Nagi N. Mansour[d], Harold S. Barnard[e], Alastair A. MacDowell[e], and Dilworth Y. Parkinson[e]

[a]*AMA Inc. at NASA Ames Research Center, Moffett Field, CA 94035*
[b]*STC at NASA Ames Research Center, Moffett Field, CA 94035*
[c]*University of Illinois at Urbana Champaign, Urbana, IL 61801*
[d]*NASA Ames Research Center, Moffett Field, CA 94035*
[e]*Lawrence Berkeley National Laboratory, Berkeley, CA 94035*

Abstract

X-ray micro-tomography is a non-destructive characterization technique that allows imaging of materials structures with voxel sizes in the micrometer range. This level of resolution makes the technique very attractive for imaging porous ablators used in hypersonic entry systems. Besides providing a high fidelity description of the material architecture, micro-tomography enables computations of bulk material properties and simulations of micro-scale phenomena. This presentation provides an overview of a collaborative effort between NASA Ames Research Center and Lawrence Berkeley National Laboratory, aimed at developing micro-tomography experiments and simulations for porous ablative materials. Measurements are carried using x-rays from the Advanced Light Source at Berkeley Lab on different classes of ablative materials used in NASA entry systems. Challenges, strengths and limitations of the technique for imaging materials such as lightweight carbon-phenolic systems and woven textiles are discussed. Computational tools developed to perform numerical simulations based on micro-tomography are described. These enable computations of material properties such as permeability, thermal and radiative conductivity, tortuosity and other parameters that are used in ablator response models. Finally, we present the design of environmental cells that enable imaging materials under simulated operational conditions, such as high temperature, mechanical loads and oxidizing atmospheres.

Keywords: Micro-tomography, Porous media, Ablation

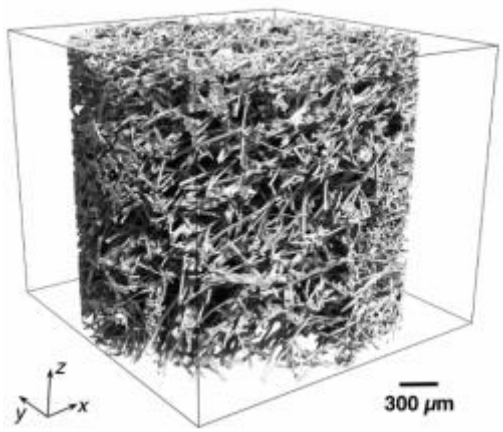

Figure 1: Micro-tomography of FiberForm, the carbon fiber preform of NASA's Phenolic Impregnated Carbon Ablator [2].

References

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*Corresponding author.
Email address: francesco.panerai@nasa.gov (Francesco Panerai)