Mesoscale Framework for Multi-Physics Simulation of Ablative Thermal Protection Systems

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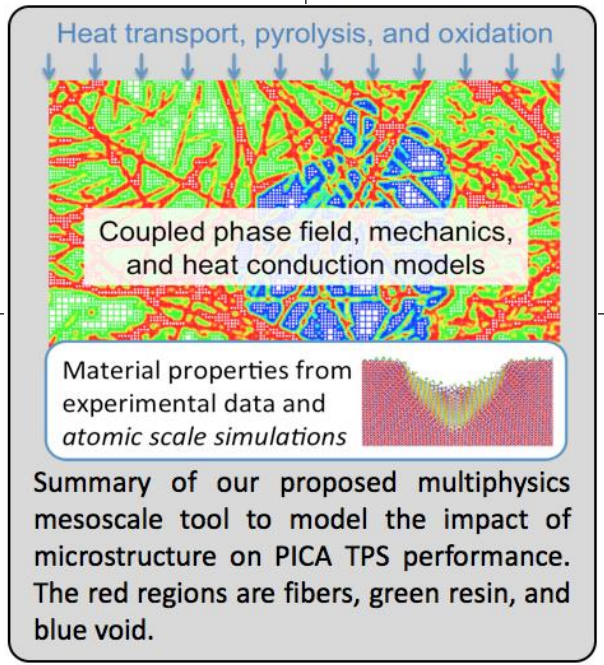
Research Objectives:

- Develop a multiphysics mesoscale tool to predict the impact of structure on the pyrolysis and ablation of phenolic ablative carbon ablator (PICA) thermal protection systems.
- Our tool will predict pyrolysis and ablation of fiber, resin, and char as well as the evolving properties of the material
- Current state-of-the-art only models fiber oxidation and the properties of the *initial* structure
- This is a fundamentally new approach (start TRL-1) and the completed tool will be validated with quantified uncertainty and used to predict the impact of structure on PICA performance (end TRL-7)



Summary of our proposed multiphysics mesoscale tool to model the impact of microstructure on PICA TPS performance. The red regions are fibers, green resin, and blue void.

Approach:

- Phase field method will be used to model pyrolysis of resin to form char and ablation through oxidation of char and fibers
- Heat transport and stress will be included with thermomechanical model
- All models will be full coupled and solved with the finite element method using the open source multiphysics object oriented simulation environment (MOOSE)
- Material properties will be obtained from experimental data and atomic scale simulations

Potential Impact:

- Data showing the impact of PICA structure on performance to inform the development of more accurate materials models for macroscale codes such as FIAT or CHAR
- Capability to optimize PICA performance by modifying initial structure
- Framework for the investigation of future TPS concepts.