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Modeling the coupling of damage and diffusion-driven oxidation in ceramic matrix composites

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The thermal stability and gradual failure mechanisms of Ceramic Matrix Composites (CMCs) make them attractive for high-temperature applications such as hot-end jet engine components; however, their complex thermal-chemical-mechanically coupled behavior presents a number of modeling challenges [1]. In particular, the diffusion-driven oxidation is tied to the thermomechanical response of the overall composite. The governing equations for equilibrium and conservation of mass are linked to address the complex coupling between oxygen diffusion, oxidation reaction, damage, and deformation in typical material architectures. The diffusion of oxidation is described with the generation term linked to the temperature-dependent reaction rates of carbon and silicon carbide. The internal variables corresponding to damage are coupled to these reaction rates as well as the internal stresses, leading to complex physics-based thermomechanical response. The developed model is implemented and tested using the finite element method (FEM).

Keywords: Ceramic Matrix Composites (CMCs); Oxidation; Damage; Diffusion; Finite element method (FEM).

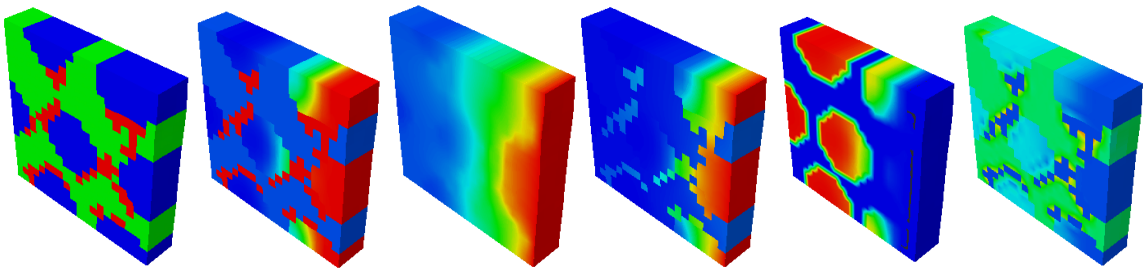

Fig.1 Oxidation creep-like simulation showing material, oxygen solubility, oxygen activity, oxygen concentration, carbon concentration, and stress, respectively.

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References: (Arial bold 12, single space), maximum 4 suggested.

[1] D. J. BAXTER and R. J. FORDHAM, “The Oxidation and Corrosion Behavior of Nonoxide Ceramic Matrix Composites,” in Comprehensive Composite Materials, 2000, pp. 221–264.