VIRTUAL TESTING AND DESIGN OF BARRIER COATING SYSTEMS

Matthew R. Begley, UCSB, Santa Barbara CA 93106
mrbegley@ucsb.edu

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The development of coating systems for high temperatures has two central challenges: (i) the selection of materials and layer architectures that are resistant to cracking and chemical attack, and (ii) the identification of active failure mechanisms and their dependency on the system’s intrinsic properties. This talk will describe two modeling frameworks that are tailored to meet these challenges. In the first framework, an automated system for analyzing delamination and mud-cracking in complex multilayers; this enables system developers to consider a broad range of materials and architectures and in turn rapidly identify promising material systems. The impact of CMAS penetration on coating reliability will be briefly discussed to illustrate potential applications of the framework. In the second framework, distributed cohesive zone models are used to develop a virtual testing framework: the framework is capable of predicting a broad range of cracking modes without a priori assumptions regarding the evolution of damage. The simulation framework exploits highly parallel computing approaches that enable simulations covering a broad range of parameter space; this enables the construction of “durability regime maps”, which indicate likely failure mechanisms as a function of material properties. Simulations will be presented illustrating the transition between crack penetration, kinking and delamination; the results demonstrate that crack kinking can occur even in the absence of a putative kink crack, and that in certain situations, cohesive strength plays a critical role in governing brittle failure modes (i.e. the relative toughness of the constituents alone is insufficient). The implications of these simulations for developing tough, CMAS resistant coatings will be discussed, with a particular focus on the role of microstructure in ceramic coatings.