

AN EXPERIMENTALLY-VALIDATED COMPUTATIONAL FRAMEWORK FOR CMAS DEGRADATION OF ENVIRONMENTAL BARRIER COATINGS

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Key Words: Environmental Barrier Coatings, CMAS, Silicate Deposit, SiC/SiC Composite.

The work addresses reactions between silicate deposits, generically known as CMAS, and yttrium disilicate (YDS), a candidate environmental barrier coating (EBC) for SiC/SiC composites. The primary goal is to elucidate effects of deposit composition, exposure temperature and time on the extent of YDS recession as well as the associated compositional and morphological evolution of reacting phases. Phase equilibrium calculations are used to assess deposits of twelve different compositions at 1300°C and 1400°C; experimental observations of YDS recession are reported for three of these compositions at both temperatures. The results show that recession depths reach terminal values for exposure times ≥ 100 h. Terminal recession depths are sensitive to deposit composition but only weakly affected by temperature. Deposits with high initial Ca:Si ratio react most severely with YDS, forming a thick layer containing an apatite reaction product interpenetrated by residual melt. The severity of the reaction decreases with decreasing Ca:Si ratio, and is least severe for deposits with insufficient Ca:Si ratio to produce apatite.

The accuracy with which the phase equilibrium calculations predict terminal recession enable an integrated modeling framework for simulation of consumption and failure of rare-earth silicate EBCs. In addition to the phase equilibrium calculations, the framework consists of two further components: (i) models for thermoelastic and physical properties of reacting phases and products; and (ii) high-throughput finite-element analyses to compute the energy release rates for steady-state channel cracking and steady-state delamination cracking after cooling. This capability is used to explore the effects of amount and composition of deposits on the propensity for fracture of YDS EBCs. The results reveal that the factors which affect coating recession, namely the deposit Ca:Si, correspondingly influence the energy release rates for fracture, due to the increased volume of thermally-mismatched reaction products.

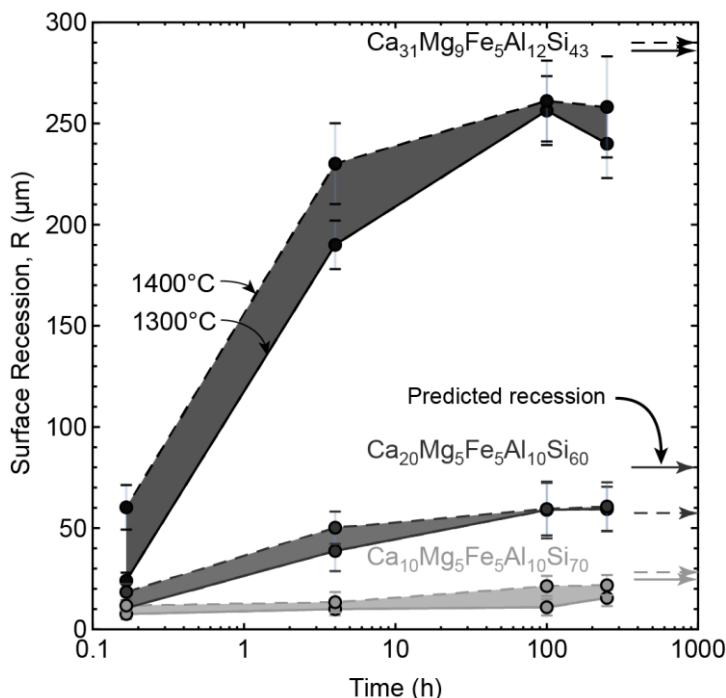


Figure 1: Measured recession and predicted terminal recession for three deposit compositions show remarkable agreement.