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Crack propagation in thermal barrier coating systems

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ABSTRACT

Thermal barrier coating systems are used on top of highly stressed components in gas turbines to protect the nickel-based substrates. A well-established thermal barrier coating system consist of the bond-coat (BC) and the thermal barrier coating (TBC). A third layer is grown during service: the thermally grown oxide (TGO) between the BC and the TBC. The coatings fail in service because of different failure mechanism which are not fully understood yet because of the complex interaction of different phenomena (e.g., creep, sintering, thermal differential expansion, diffusion, and oxidation). Therefore, a simplified model system is presented which consists of a FeCrAlY bulk material and a TBC applied as a top coat by atmospheric plasma spraying. This simplified model system is used to study the influence of BC and TGO creep and the influence of the interfacial roughnesses. A finite element (FE) model of crack propagation in the model system was developed and compared to experimental series. The crack direction in the FE model is calculated by using short trial cracks in different directions. The direction of the crack in the coating system is defined as the crack direction with the maximum energy release rate. It was found that microcracks form primarily near the roughness valleys and are more likely in the fast-creeping samples inside the TBC despite of the low creep strength. The higher probability of microcracks in these samples is because of the high energy release rate of initial delaminations. The highest life-time was measured in fast-creeping Fecralloy samples in combination with fast-creeping TGOs. The decelerated delamination growth rate in this sample is because of the interaction of delaminations with segmentation cracks. Therefore, an initial and fast-creeping TGO has the high potential to extend the life-time of the model systems. Hence, applying an initial and fast-creeping TGO on a fast-creeping BC is a possible optimization strategy for real thermal barrier coating systems.