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Modelling the Fracture and Healing Behaviour of Self-healing Thermal Barrier Coatings Under Thermomechanical Cycling

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The lifetime of Thermal Barrier Coating (TBC) systems is often limited by cracking due to thermal stresses caused by the mismatch in thermomechanical properties of different layers in the TBC system, namely the ceramic Top Coat (TC), the metallic Bond Coat (BC) and the Thermally Grown Oxide (TGO) layer. A promising approach to extend the lifetime of such TBC systems is to incorporate a particle-based healing mechanism whereby the microcracks in the TBC are autonomously healed, preventing a catastrophic failure. To analyse this system, a new modelling framework was developed, which is capable of simulating fracture and healing behaviour of self-healing TBC systems under thermomechanical loading. The major task in this process lies in formulation and implementation of a crack healing model with a capability to simulate recovery of mechanical properties. A cohesive zone-based constitutive law [1], which was originally developed to model fracture, is extended to include a healing variable to simulate the crack healing process. For analysis of TBC failure, a concurrent multiscale modelling approach is considered in which an explicitly resolved TBC unit cell is embedded in a much larger domain of the TBC. An experimentally-obtained TGO growth curve is coupled to the thermomechanical cyclic analyses to simulate the oxidation-induced stresses in the TGO and TC layers. To simulate cracking, cohesive element-based FE analyses are carried out whereby cohesive elements are embedded throughout the FE mesh regions in the unit cell. The developed modelling framework can be used as a tool for analysis and design of self-healing TBC systems.

REFERENCES

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