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Suspension plasma spraying of GdPO4 coatings: influence of process parameters on microstructure and performance

Abstract:
Thermal barrier coatings (TBCs) protect Ni-based superalloy substrates from elevated operating temperatures and corrosion. The current state-of the-art material, yttria-stabilised zirconia (YSZ), undergoes a detrimental phase transformation around 1170 °C and has poor resistance to calcia-magnesia-alumino-silicate (CMAS), which makes it unsuitable for next generation gas turbine and aero engines that will operate in CMAS-prone environments. Rare-earth phosphates are an emerging family of materials which offer improvements over YSZ and common alternatives such as gadolinium zirconate (Gd2Zr2O7). Gadolinium phosphate (GdPO4) exhibits phase stability up to 1700 °C and has excellent CMAS resistance due to the fast formation of a dense apatite reaction layer, both contributing to a longer TBC lifetime. Suspension plasma spraying (SPS) is a promising route to deposit a range of microstructures such as columnar and dense vertically cracked (DVC) which have improved strain tolerance during thermal cycling. This study develops the first SPS GdPO4 coatings and investigates how processing parameters - gas mixture, torch current, total gas flow, and stand-off distance (SoD) - affect their microstructure, phase composition, and performance during thermal cycling and CMAS exposure. A range of multi-phase GdPO4 coatings were deposited with a range of columnar and DVC-like microstructures. Increasing net power resulted in more loss of phosphate and poorer CMAS performance with lower cycles to failure, whilst lower net power retained phosphate which significantly reduced Ca and Si infiltration compared to conventional SPS YSZ coatings. A single-layer SPS GdPO4 coating could be used as a highly effective barrier for CMAS protection in TBC systems.