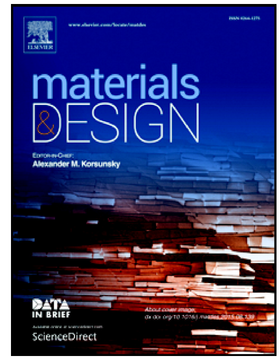

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Tailoring columnar microstructure of axial suspension plasma sprayed TBCs for superior thermal shock performance

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Abstract

This paper investigates the thermal shock behavior of thermal barrier coatings (TBCs) produced by axial suspension plasma spraying (ASPS). TBCs with different columnar microstructures were subjected to cyclic thermal shock testing in a burner rig. Failure analysis of these TBCs revealed a clear relationship between lifetime and porosity. However, tailoring the microstructure of these TBCs for enhanced durability is challenging due to their inherently wide pore size distribution (ranging from few nanometers up to few tens of micrometers). This study reveals that pores with different length scales play varying roles in influencing TBC durability. Fracture toughness shows a strong correlation with the lifetime of various ASPS TBCs and is found to be the prominent life determining factor. Based on the results, an understanding-based design philosophy for tailoring of the columnar microstructure of ASPS TBCs for enhanced durability under cyclic thermal shock loading is proposed.

Keywords

Suspension Plasma Spraying; Thermal Barrier Coatings; Thermal Shock Lifetime; Superior Performance; Pore Size Distribution; Fracture Toughness

1 Introduction

Thermal barrier coatings (TBCs) are frequently used to provide thermal and oxidation protection to hot section components of gas turbine engines at high temperatures [1]. The performance of TBCs is measured by their ability to provide good thermal insulation and last long under harsh operating conditions [2], [3]. The need to suppress degradation of TBCs due to various changes associated with sustained high temperature exposure, such as phase transformation, sintering, oxidation etc., has become more compelling as the operating temperature of gas turbines is being constantly increased to improve efficiency [4]–[6]. High temperature exposure under severe cyclic thermal shock conditions, as experienced during frequent take-off and landing of aero-engines, can accelerate premature failure of TBCs due to excessive thermal gradients and accompanying microstructural changes [7], [8].

Microstructures of TBCs in actual use on hot-section components of aero turbine engines are of both lamellar [9] and columnar [10] type. The former is produced by atmospheric plasma spraying (APS) [9] and the latter by electron beam physical vapor deposition (EBPVD) [10]. APS sprayed lamellar TBCs are known to provide