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Thermal Conductivity of Ceramic Thermal Barrier and Environmental Barrier Coating Materials

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THERMAL CONDUCTIVITY OF CERAMIC THERMAL BARRIER AND ENVIRONMENTAL BARRIER COATING MATERIALS

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ABSTRACT

Thermal barrier and environmental barrier coatings (TBCs and EBC's) have been developed to protect metallic and Si-based ceramic components in gas turbine engines from high temperature attack. Zirconia-yttria based oxides and $(Ba,Sr)Al_2Si_2O_8$ (BSAS)/mullite based silicates have been used as the coating materials. In this study, thermal conductivity values of zirconia-yttria- and BSAS/mullite-based coating materials were determined at high temperatures using a steady-state laser heat flux technique. During the laser conductivity test, the specimen surface was heated by delivering uniformly distributed heat flux from a high power laser. One-dimensional steady-state heating was achieved by using thin disk specimen configuration (25.4 mm diam and 2 to 4 mm thickness) and the appropriate backside air-cooling. The temperature gradient across the specimen thickness was carefully measured by two surface and backside pyrometers. The thermal conductivity values were thus determined as a function of temperature based on the 1-D heat transfer equation. The radiation heat loss and laser absorption corrections of the materials were considered in the conductivity measurements. The effects of specimen porosity and sintering on measured conductivity values were also evaluated.

INTRODUCTION

Environmental barrier coatings (EBC's) have been developed to protect Si-based ceramic components in gas turbine engines from high temperature environmental attack [1–3]. With continuously increasing demands for significantly higher engine operating temperature, fuel efficiency and better engine reliability, future EBC systems must be designed for both thermal and environmental protections of the engine components in gas turbine combustion gas environment [4]. In particular, thermal barrier functions of EBC's become a necessity for reducing the engine component thermal loads and chemical reaction rates, thus maintaining required mechanical properties and durability of these components. The development of advanced thermal barrier and environmental barrier coatings (TBC's and EBC's) will directly impact the successful use of ceramic components in advanced engine systems.

Plasma-sprayed ZrO_2-8 wt% Y_2O_3, and $(Ba,Sr)Al_2Si_2O_8$(BSAS)-mullite coatings have been successfully used as thermal barrier coatings for superalloy components, and environmental barrier coatings for SiC/SiC ceramic matrix composite (CMC) systems, respectively. In this study, a laser steady-state heat flux technique is established to evaluate high temperature thermal conductivity of both the hot-pressed and plasma-sprayed TBC/EBC materials. The thermal conductivity data are of great importance for future advanced coating design.

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