Anisotropic Thermal Diffusivity of a Thermal Barrier Coating

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Thermal barrier coatings (TBCs) are used as heat and wear shields of gas turbine blades. There are strong needs to evaluate thermal conductivity of coating for thermal design and use. Thermal conductivity of the bulk material is obtained as the product of the thermal diffusivity, the specific heat capacity and the density above room temperature in many cases. The TBC consists of ceramics-based top-coat and bond-coat on the metal substrates in many cases. Usually, the thermal conductivity of thickness direction was focused because the heat mainly diffuses from the surface of the top-coat to the substrate. However, there are some hot spot on the gas-turbine wings related to temperature gradient in the turbine. According to this, we considered that the in-plane thermal conductivity also important for the thermal design of the gas turbine. The top-coat samples were prepared by plasma spray processing for this study. These were self-standing samples removed from substrates. We measured thermal diffusivities along to thickness direction and in-plane direction of these samples using the laser flash method and the periodic heating method. For in-plane thermal diffusivity measurement by the periodic heating method, the frequency and sample thickness were important factors in order to obtain reasonable results. It was found that thermal diffusivity of the top-coat was anisotropic. The microstructure of the sample was observed by the scanning electron microscope. There were many splats and micro cracks in the coating. We confirmed a relationship between anisotropy of thermal diffusivity and micro-structure of the ceramics-based top-coat of TBC.