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SENSOR COATINGS FOR HIGH-TEMPERATURE MEASUREMENTS IN SPACE APPLICATIONS

Abstract

In several space applications, components such as rocket nozzles and rocket skins are exposed to extremely high temperatures. The sources of these high temperatures are the aerodynamic heating, the heat generated by electronic components inside the spacecraft and the need for higher engine efficiency. Thus, high-temperature materials are crucial in space components.

However, material selection in these harsh conditions can be carried out only when highly accurate temperature profiles are known. Since these temperatures arise quickly and under severe environments, standard thermocouples fail before any valuable temperatures are measured. Other temperature measurement techniques such as infrared cameras and pyrometry need optical access and the results are influenced by changes in emissivity which can occur during operation. Offline techniques, in which the peak temperature information is stored and read-out later, overcome the need for optical access during operation. However, the available techniques, such as thermal paint and thermal crystals cannot measure above 1400 °C. Therefore, a new measurement technique is required to acquire temperature data at extreme temperatures.

To meet this challenge, Sensor Coating Systems (SCS) is focused on the development of Thermal History Coatings (THC) that measure temperature profiles in the $900 - 1600\,^{\circ}C$ range. THC are oxide ceramics deposited via air plasma spraying process to produce a durable coating. This innovative temperature profiling method uses optically active ions in a ceramic host material that start to phosphoresce when excited by light. After being exposed to high temperatures the host material irreversibly changes at the atomic level affecting the phosphorescence properties which are then related to temperature through calibration. It is a technique that records the maximum exposure temperature in such a way that it can be determined later when the component has cooled.

This paper covers the principles of this new technique and demonstrates its capabilities for high temperature applications. The THC was applied to environmental barrier coatings developed by NASA, as part of a ceramic-matrix-composite system and heat treated in excess of 1500 °C. The results indicate

the THC could provide a unique capability for measuring high temperatures on next generation materials. Further analysis of the material through electron microscopy and X-ray diffraction has improved the understanding of the link between the material properties and their luminescence characteristics.