**Fiber Optic Temperature Sensors in TPS: Arc Jet Model Design & Testing**

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**Introduction**

This poster describes an IFOS-NASA collaboration resulting in the first-ever arc jet testing of fiber optic temperature sensors. IFOS Corp. has developed fiber optic temperature sensing technology for Thermal Protection System (TPS) materials. Fiber optic-based temperature sensors offer potential improvements over state-of-the-art thermocouples (TCs), as described below.

**Background: Fiber Bragg Grating Based Sensing**

- Fiber Bragg Gratings (FBGs) are designed to reflect precise wavelengths of light.
- Many FBGs, each of a unique wavelength, can be produced on a single fiber.
- Reflected FBG spectrum is temp. dependent.
- Compared to thermocouples (TCs), fiber optics have lower thermal conductivity (therefore perturb local thermal gradient less) and are non-electrically conductive (which is problematic for some TPS materials with TCs).
- Fibers with many FBG sensors offer higher spatial resolution of temperature sensing compared to TCs.

**Arc Jet Testing & Preliminary Results**

- A total of 18 PICA and BPA models were arc jet tested at a cold wall heat flux of 240 W/cm\(^2\), at a pressure of 9 kPa, and for durations of 15 to 60 seconds.
- In each arc jet run, one TC model and four fiber models were tested.
- Testing was recently completed, data analysis is ongoing.

**Arc Jet Model & Fiber Optic Plug design**

- The primary design consists of 1” diameter plug with fiber optic wound around the circumference in a precisely-machined groove to align FBGs along two axes.
- Five FBGs along centerline axis and 5 offset to detect sidewall heating.
- 4 mm long FBGs parallel to the outer surface to limit in-depth thermal conduction.
- Thermocouple and fiber optic models were instrumented with the same sensor locations to facilitate comparison of the two techniques.

**Conclusions & Future Direction**

- Fiber optic temperature sensing of TPS materials in a planetary entry-relevant heating environment has been demonstrated based on IFOS interrogation of FBG-reflected spectra in PICA and BPA arc jet coupons.
- Fiber plug design allows for many sensors per plug, high data rates (kHz).
- In-plane distribution of sensors enables assessment of 2D/3D heating effects (still under evaluation for this test series).
- fiberglass-based FBG sensing is reliable to at least 1000 °C.
- High temperature fiber optic sensing limits could be increased using sapphire fibers, which is currently under development by IFOS.
- Other parameters tested during this series include the effect of FBG size (trading signal for location precision with decreasing size) and a vertical fiber orientation are still under evaluation.

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