National Aeronautics and Space Administration

TBD

High Temperature / High Frequency Temperature Measurement: Achieving MHz response at Temperatures > 1000 deg-F

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EXECUTIVE SUMMARY

High frequency temperature measurements are not possible with current SOA temperature measurement devices at temperatures higher than ~700 deg-F. Temperature measurements above ~1000 deg-F are typical for entry vehicle thermal protection systems (TPS), rocket engines, ram/scramjet engines, etc. A new technology capable of achieving ~1200 deg-F temperature measurements with MHz response has been achieved. Investigations are underway to extend the concept to even higher temperatures.
U.S. Patent Application submitted (Patent Pending: #63/599,787).

INNOVATION

High temperature materials typical of entry vehicle TPS, rocket engine internal components, ramjet and scramjet nozzle surfaces, etc can induce very large thermo-mechanical stress and strain due to high temperature gradients and differing coefficients of thermal expansion (CTE). So called CTE mismatch is a design consideration for all thin surface coatings and was identified through demonstration to be a large contributing factor in failure of thin-film temperature measurement devices. High frequency temperature measurements motivate for the use of very thin temperature measurement devices. The innovation involves addressing the CTE mismatch and stress/strain concentrations that occur between the typical larger diameter electrical lead wires, and the thin-film desired for high frequency response.

COLLABORATION

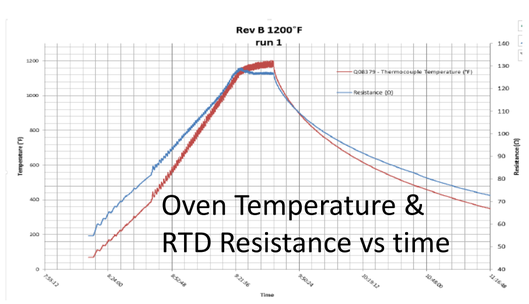
CUBRC Advantage through technology
Buffalo NY

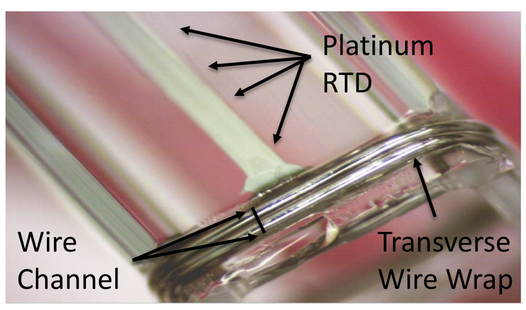
JSC ENGINEERING NASA
Engineering Directorate
ES3 Materials Lab

Development History

2011 – MHz capable Platinum (Pt) RTD applied to Orbiter RCG tile. Open circuit near 900 deg-F experienced on cool-down.
2015 – Concept for relieving CTE effects documented
2016 – Innovation Disclosure submitted
2019 – MHz capable Pt RTD application on Pyrex substrate
Joint NASA/Cubrc Innovation Disclosure
2021 – JSC Innovation Board approved patent pursuit
Supported by market survey demonstrating interest
Innovation Office $ approved to develop patent application
2022 – Pt Sputtered thin-film absorbed/dispersed into RCG above 1000 deg-F; SEM & EDS results
2023 – Lab investigations of fumed silica based buffer layer
Final updates to patent application prepared
U.S. Patent submission imminent

Original 2019 Cubrc Prototype RTD on Pyrex

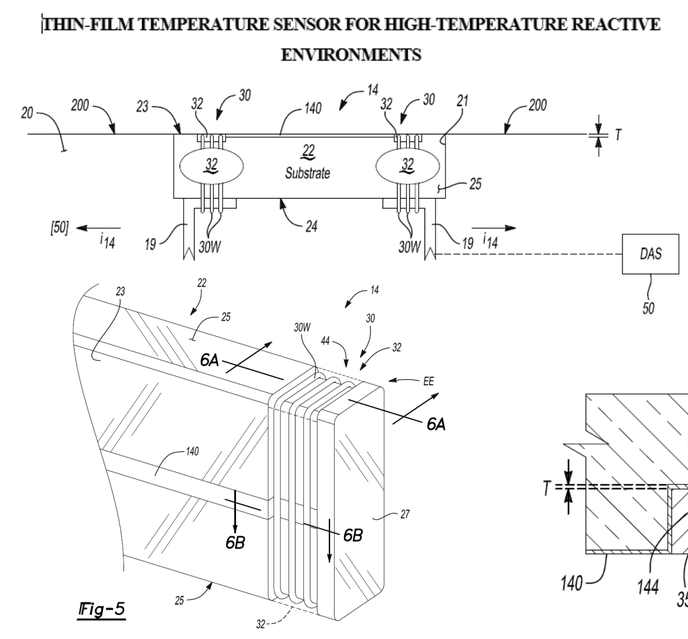


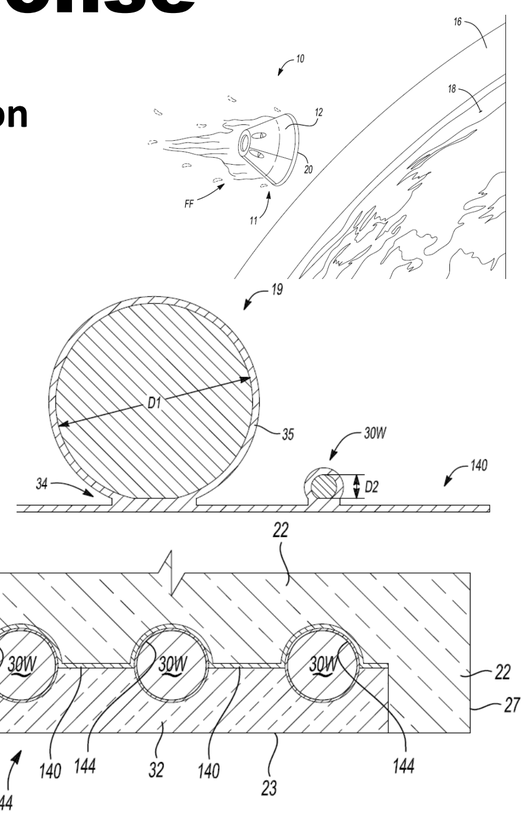


Patent Submission

Attorney Docket Number: MSC-26322-1
PATENT APPLICATION

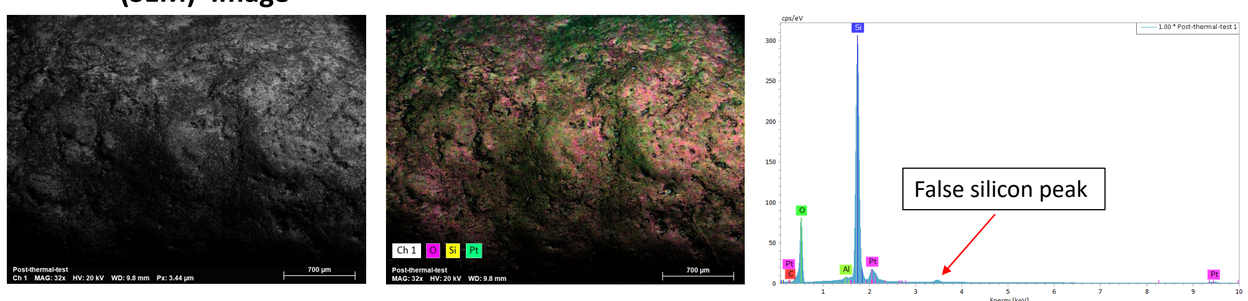
THIN-FILM TEMPERATURE SENSOR FOR HIGH-TEMPERATURE REACTIVE ENVIRONMENTS





Platinum Thin-Film on RCG Investigations

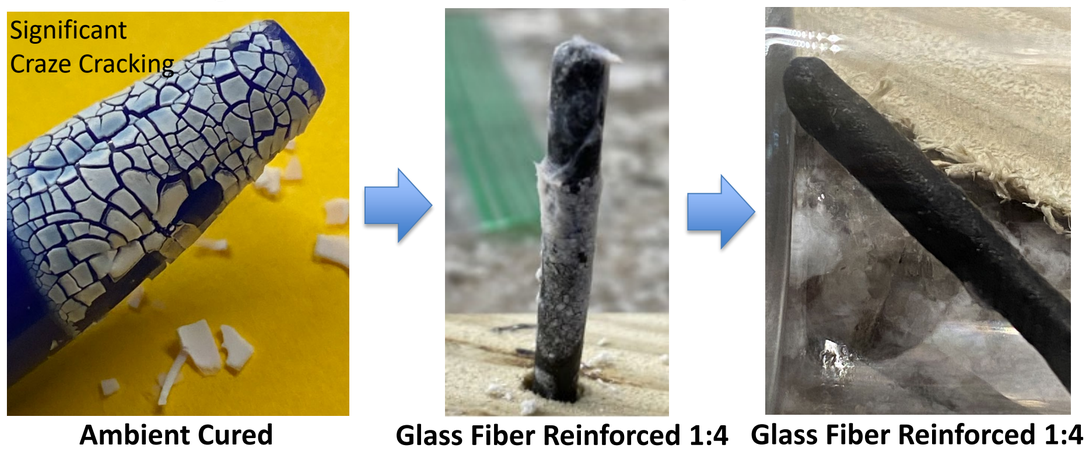
Scanning Electron Microscope (SEM) Image | Composite EDS Image | EDS Spectrum



Benchtop RCG Investigations of Pt thin-film supported by ES3/Materials Lab, Mike Fowler/ES, Frank Samonski/JESC

Fumed Silica on RCG Investigations

Xerogel Trials with Acetone:Fumed Silica / Volumetric Ratio 1:2



Ambient Cured | Glass Fiber Reinforced 1:4 Ambient Cured | Glass Fiber Reinforced 1:4 Enclosure Cured

Desired Fumed Silica Buffer Layer Achieved with Enclosure Cured 2:1 Xerogel and 1:4 Glass Fiber

OUTCOMES & INFUSION

- Concept for relieving high temperature thermal expansion (CTE) effects on thin-film connection to lead wires validated
- Key aspects of innovation include: transverse wire wrap relative to thin-film, colloidal Platinum bridging of wire to thin film, channel cut for wire wrap to enable manufacture, channel back-fill with ceramic adhesive for robustness
- >1200 deg-F, MHz capable Resistance Temperature Device (RTD)
  - SOA capability is currently about 700 deg-F
  - New device TRL ~5 (relevant lab environment)
  - Straight-forward extensibility to TRL 9 with flight test
- U.S. Patent application in-work

FUTURE WORK

- Utilize Glass Fiber/Xerogel buffer layer on RCG, attempt Pt RTD fabrication
- Upon Patent filing, increase visibility for potential ground test / flight utilization for TRL advancement

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NTR#(s) MSC-26322-1 & MSC-26415