Ultrahigh Temperature Capacitive Pressure Sensor

To monitor engine health and improve aircraft safety

Robust, miniaturized sensing systems are needed to improve performance, increase efficiency, and track system health status and failure modes of advanced propulsion systems. Because microsensors must operate in extremely harsh environments, there are many technical challenges involved in developing reliable systems. In addition to high temperatures and pressures, sensing systems are exposed to oxidation, corrosion, thermal shock, fatigue, fouling, and abrasive wear. In these harsh conditions, sensors must be able to withstand high flow rates, vibration, jet fuel, and exhaust. In order for existing and future aeropropulsion turbine engines to improve safety and reduce cost and emissions while controlling engine instabilities, more accurate and complete sensor information is necessary. High-temperature (300 to 1,350 °C) capacitive pressure sensors are of particular interest due to their high measurement bandwidth and inherent suitability for wireless readout schemes.

The objective of this project is to develop a capacitive pressure sensor based on silicon carbon nitride (SiCN), a new class of high-temperature ceramic materials, which possesses excellent mechanical and electric properties at temperatures up to 1,600 °C.

Applications

NASA

- Planetary exploration mission to Venus
- Integrated vehicle health management and control for onboard systems:
  - Propulsion systems, including launch and station-keeping, turbo pump assemblies, thrust chamber assemblies in liquid rocket motors, and nuclear thermal propulsion
- Energy generation systems, such as fuel cells, Stirling engines, and nuclear reactors
- *In situ* resource utilization systems

Commercial

- Commercial and military jets
- Fossil fuel (coal and natural gas) power generation
- Nuclear power generation
- Concentrating solar thermal power generation

Phase II Objectives

- Optimize SiCN formulations to create materials with optimized dielectric and loss tangent properties
- Develop an SiCN device fabrication process to realize air/electrode gap sizes of less than 5 μm
- Fabricate improved prototype SiCN sensor devices, prototype packaging hardware, and signal conditioning electronics
- Perform laboratory-scale performance testing
- Based on results of initial integrated hardware testing, redesign and rebuild prototype hardware for relevant environment testing in NASA and/or partner test systems to achieve a technology readiness level (TRL) 5–6

Benefits

- Significantly reduces payload weight and volume
- Enables enhanced health monitoring via a noninvasive, on-engine system
- Does not require cooling

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