

Wireless High Temperature Strain Sensors for Structural Health Monitoring

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Introduction

- The IVHM project recommends nine priorities for future IVHM research. Strain measurement technology is one of the nine recommendations. The Decadal Survey of Civil Aeronautics: Foundation for the Future, identified IVHM as the top NASA and national priority within the area of materials and structures. The survey also identified IVHM systems that warrant attention over the next decade such as “locally self-powered, wireless microelectromechanical sensors of various types tiny enough that very large numbers of sensors become practical.” Standard strain gages have been used to detect cracks in aircraft, and have been used to monitor load conditions and fatigue in airframes. High temperature devices will be able to monitor structural health in areas that are inaccessible today.

Objectives

- **Develop a passive wireless high temperature Surface Acoustic Wave (SAW) strain sensor:**
 - The device will have an integrated antenna which will power the device from RF energy.
 - The device will monitor structural health by measuring strain in a high temperature environment.
 - The device will communicate using RF spread spectrum Orthogonal Frequency Coding (OFC) communication scheme.

Approach

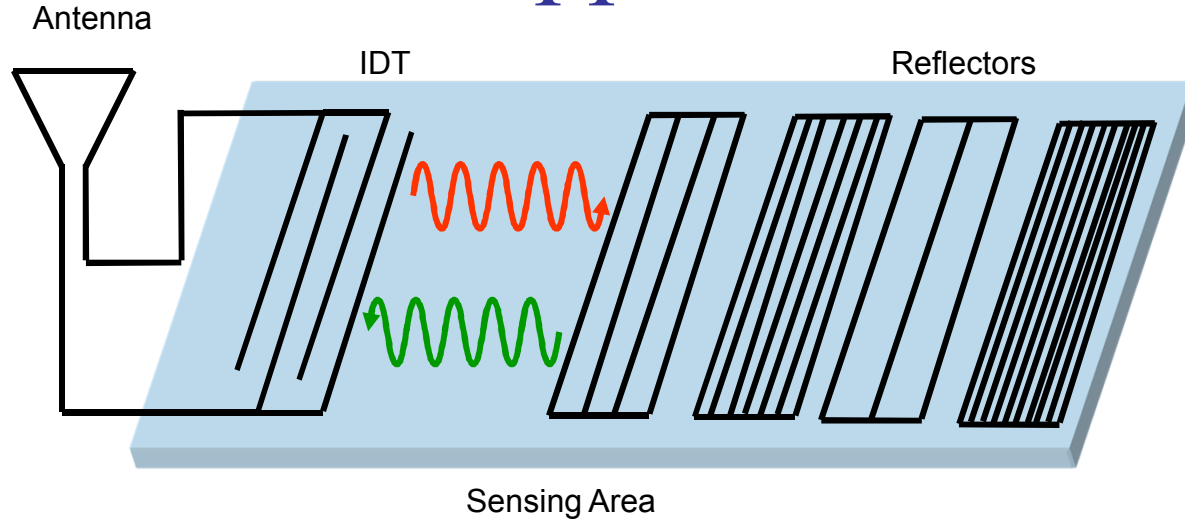
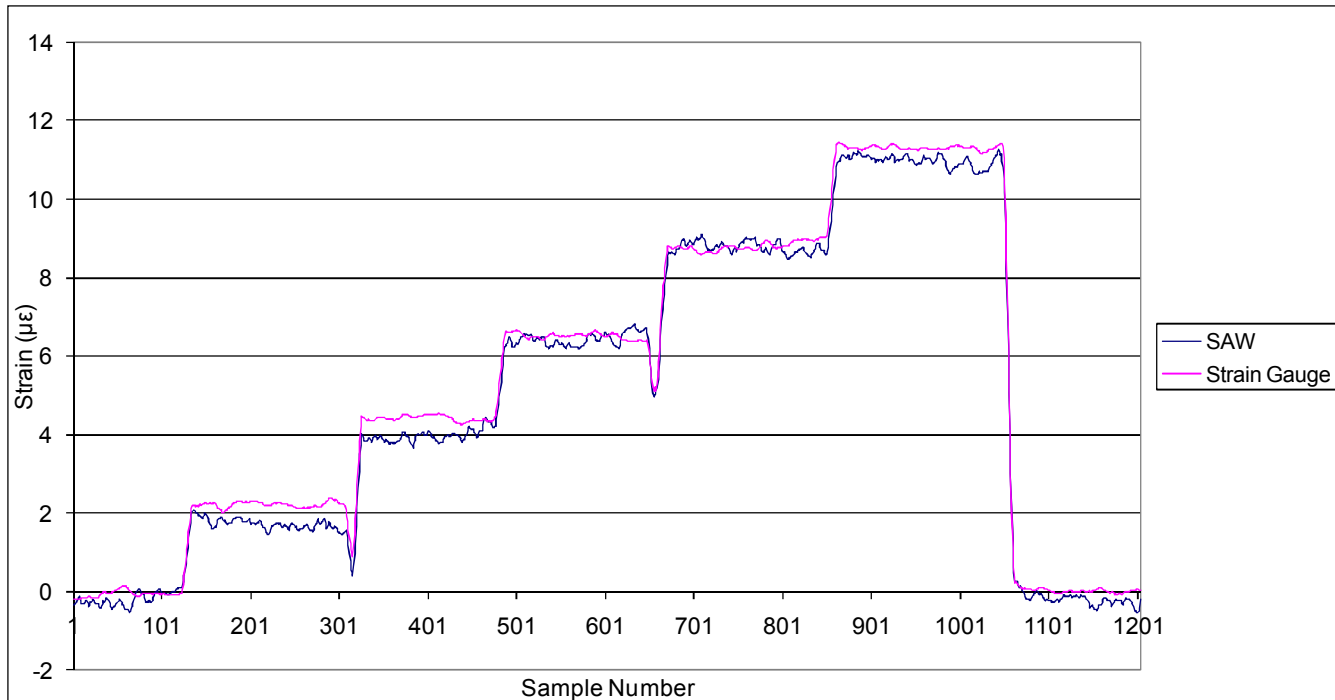


Figure 1. Passive wireless high temperature Surface Acoustic Wave (SAW) strain sensor with Orthogonal Frequency Coding (OFC)..

- Develop high temperature wireless SAW sensor that utilizes OFC Coding for spread spectrum communication and unique sensor identification.
- Prototypes will be fabricated and tested to measure strain at elevated temperatures.
- Next antennas will be integrated with the sensor to create passive wireless high temperature strain sensors. These devices will be tested wirelessly at elevated temperatures.

Recent Accomplishments

A prototype device with OFC coding but without an antenna has been tested at room temperature. The device uses Langasite, a new piezoelectric material that has been shown to operate as temperature sensor up to 950 °C. The initial testing demonstrates that the device can measure micro strain and that the data agrees very well with conventional strain gauges at micro strain levels.



Benefits/Payoffs

- Benefits are a significant reduction in :
 - Size, weight, and power for structural health monitoring.
- Payoff
 - Vehicle health monitoring in harsh temperature environment.
 - Easy to retrofit on existing structures.
 - Wireless sensors without batteries.
 - Real-time structural health monitoring.
- Customers that would benefit from the system:
 - ARES (radiation tolerant, harsh environment tolerant, etc.)
 - VSST Project (aircraft structures & propulsion systems)
 - Hypersonic aerospace vehicles
 - High temperature industrial applications

Status

- Device models incorporating OFC reflectors have been developed.
- A prototype device with OFC coding but without an antenna has been tested at room temperature and has been shown to detect micro strain. The device uses Langasite, a new piezoelectric material that has been shown to operate as temperature sensor up to 950 °C.
- The University of Central Florida has been identified as a partner for this project for aid in fabrication and OCF expertise.

Future Work

- Fabricate prototype design and test on a Load Frame.
- Test and characterize the device on the load frame at elevated temperatures.
- Integrate antenna and test wirelessly on a load frame at elevated temperatures.

Conclusion

- Development of this system would enhance our ability to retrofit sensors on vehicles where high temperatures prohibit sensor currently.
- This capability would extend our ability to monitor the operational lifetime of the aging aircraft fleet and insure the safety of next generation of spacecraft.
- This work will reduce the size, weight, and power, along with the amount of expensive radiation tolerant electronics required for monitoring spacecraft structures (SAW devices are inherently radiation tolerant up to 10 MRads).