

# Summary

Optical Fiber Sensors (OFSs) are a well-established technology that has significantly expanded its range of applications in recent years, encompassing industries from oil and gas to aerospace. Their advantages over traditional sensors include low weight, compact size, high sensitivity, multiplexing capabilities, and immunity to electromagnetic interference. These unique features have positioned OFSs as an attractive solution for deployment in extreme and challenging environments where conventional sensors face limitations or cannot operate. Sectors such as aerospace and biomedical, traditionally characterized by lengthy adoption cycles for new technologies, are now actively exploring their potential. Moreover, the versatility of OFSs allows their use in diverse sensing applications, such as strain, structural health, temperature, and chemical monitoring.

Despite their versatility, the adoption of OFSs has been limited by the need for meticulous system design and specialized packaging to ensure proper operation. These requirements increase system complexity and necessitate more expensive instrumentation compared to traditional sensor systems. However, advancements in cost-reduction strategies and improvements in sensor reliability have recently driven renewed interest in their widespread application.

In the context of the emerging space revolution, characterized by automated, intelligent, and self-aware crewless vehicles and reusable spacecraft, sensors are becoming critical components in control systems. Optical fiber sensors, with their minimal footprint and electromagnetic immunity, offer significant potential in aerospace. Nonetheless, the harsh radiation environments and extreme operating conditions present challenges that require close collaboration between aerospace vehicle designers and fiber optic sensor specialists.

The broad spectrum of optical fiber sensors enables the selection of optimal configurations tailored to specific applications. These sensors can generally be categorized into two groups: distributed sensors, such as Brillouin-based systems, and point sensors, like Fiber Bragg Gratings (FBGs).

This thesis explores the industrial application of FBGs optical fiber sensors in hostile environments, with a particular focus on aerospace. Leveraging the inherent flexibility of OFSs and building on extensive integration research conducted during this study, various applications have been developed. These include replacing traditional thermal sensors with optical fiber sensors in space applications and enhancing strain sensing capabilities through integrated systems designed to amplify sensitivity.

Specifically, this work investigates the replacement of conventional thermocouples with FBGs sensors for thermal analysis of multilayer insulation (MLI) systems. Various configurations aimed at optimizing system stability and precision were evaluated under conditions simulating the vacuum of space, encompassing both pressure and temperature parameters.

Furthermore, the integration of these sensors into windows designed for thermal flux analysis was studied, aiming to minimize visual impact while maintaining comprehensive thermal monitoring of entire panels. This approach enabled continuous monitoring capabilities and included the investigation of amplification effects through the strategic selection of packaging materials.

Finally, surface treatments and packaging designs were examined to enhance the sensitivity of FBGs sensors for targeted applications.

This research demonstrates that, through a careful combination of adhesion system optimization, advanced surface treatments and careful design, it is possible not only to deploy these sensors in high-demand sectors but also to significantly enhance their performance characteristics.