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From Particle Detectors to Aircraft: Technology Transfer of Fibre Bragg Grating Sensors for Wing Structural Monitoring

Technologies developed for high-energy physics (HEP) experiments frequently operate under demanding constraints on sensor size, reliability, cabling, electromagnetic compatibility and remote accessibility. These requirements have driven the development of fibre-optic sensor (FOS) systems for environmental monitoring within the ATLAS experiment at CERN. Many of the same characteristics are desirable in aerospace structural monitoring, where large numbers of sensing points must be integrated into lightweight structures without significantly increasing mass or wiring complexity. This work investigates the transfer of fibre Bragg grating (FBG) sensing techniques from particle-detector instrumentation towards structural monitoring of aircraft wings.

An array of FBG sensors is applied at selected locations along an aircraft wing structure to measure strain under controlled mechanical loading. Changes in Bragg wavelength are converted to local strain using experimentally determined sensor calibrations, allowing the spatial strain distribution across the structure to be reconstructed as the applied loading is varied. Particular attention is given to sensor placement, strain transfer between the wing structure and optical fibre, temperature compensation and the multiplexing of multiple FBG sensing points along a common optical fibre.

The measured strain response is used to investigate wing bending and deformation and to identify regions experiencing increased structural loading. The multiplexed architecture enables several locations to be interrogated through a single optical fibre, demonstrating a pathway towards lightweight sensor networks capable of continuously monitoring large aerospace structures. Such measurements can ultimately contribute to structural health monitoring through the identification of abnormal strain distributions, load histories and changes in structural behaviour.

The study demonstrates a technology-transfer pathway between HEP instrumentation and aerospace engineering. Fibre-sensing expertise developed for monitoring inaccessible and challenging regions of particle detectors can be adapted to aircraft structures, where low sensor mass, reduced cabling, electromagnetic immunity and multi-point sensing are similarly advantageous. The work highlights the broader potential for technologies originating in fundamental physics experiments to contribute to intelligent structural monitoring and condition-based maintenance in aerospace systems.

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