Embedding optical sensors in additive layer manufactured metallic components for conditional monitoring in harsh environments

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The use of optical fibre sensors, such as fibre Bragg gratings (FBG), provides opportunity for conditional health monitoring of a structure or process. FBGs allow for in-situ measurement of temperature and strain. The measurement of these parameters is important for advanced and complex structures where these sensors can provide real-time information to support lifetime condition monitoring.

In general sensor reliability drops as the temperature, moisture content and environmental corrosiveness increases. These limitations can be overcome by embedding sensors in high melting point metals to extend their operation for use at elevated temperatures and within harsh environments.

A fibre embedding process chain has been devised to facilitate embedding of optical fibres within additive layer manufactured (ALM) stainless steel (SS) components. The ALM process provides access to any point of the component during manufacture, which is beneficial for the embedding of sensors inside a functional component. Furthermore, parts with complex geometries and internal features, unattainable with other forms of manufacture, become feasible using ALM technologies, but pose additional challenges for accurate modelling and external monitoring. Embedding sensors directly into such structures is a possible solution to this challenge.

Selective laser melting is a powder bed fusion ALM technique where a laser selectively melts metallic powder in accordance with the geometrical data of the build layer, defined by a 3D CAD model. The small spot sizes achievable by SLM systems are well suited for fibre embedding as the localised melt pools limits interaction through conduction with the surrounding material. A system has been set up for use with SS-316 powder, that is capable of embedding fibres in test structures. The high nickel content within SS-316 allows for intermixing of the host material with the fibre protective nickel jacket thereby bonding the fibre to the surrounding material.