Measurement with fiber optics

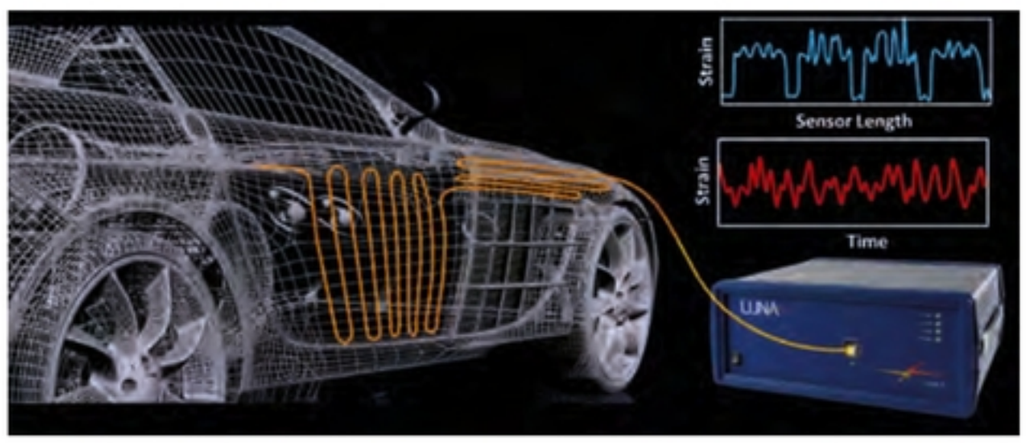
Luna Innovations develops high-definition fiber-optic sensing for in-situ measurement of strain and temperature

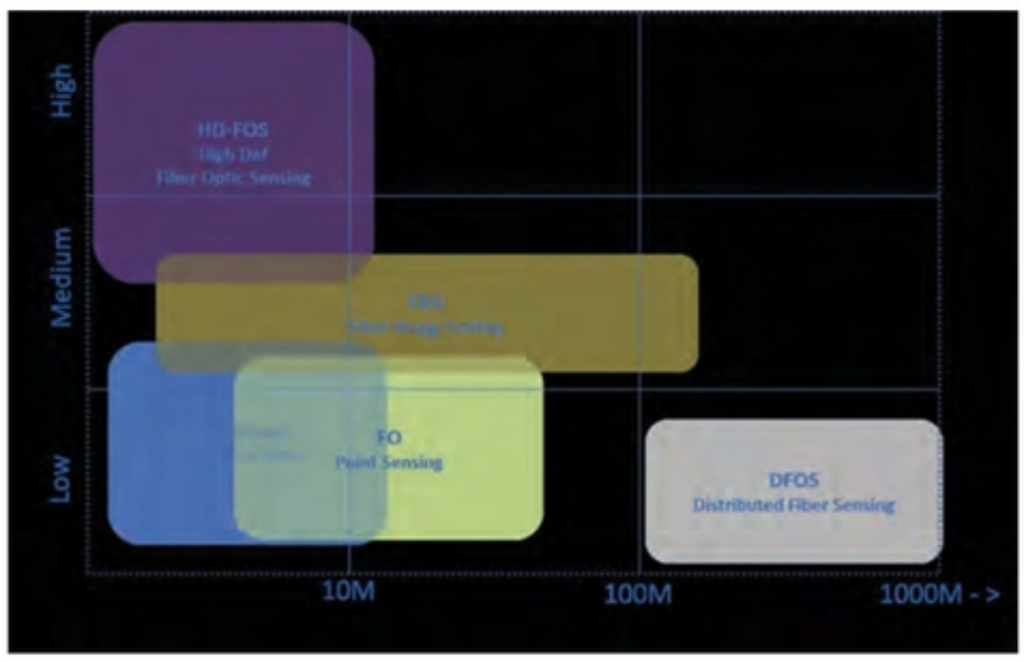
The automotive industry is in the early stages of a radical transformation driven by an increasingly stringent regulatory and consumer environment aimed at reducing carbon emissions. These pressures manifest themselves in research and development departments competing to successfully implement new lightweight composite materials as well as in continued research into hybrid and electric vehicle powertrains.

Luna Innovations's ODiSI system, using high-definition fiber-optic sensing (HD-FOS) technology, offers the unique capability for high-density *in situ* measurements of temperature and strain.

HD-FOS is a relatively new, but timely, entrant to the test and measurement arena. While having many of the advantages of fiber-optic and distributed systems, it distinguishes itself by virtue of high spatial resolution – the density of measurements per length of sensor.

When illuminated, fiber-optic cables have the equivalent of an optical fingerprint and this fingerprint will change, in a predictable and repeatable way, in response to changes in temperature and in response to fiber elongation when bonded to a structure experiencing strain. This fiber-optic cable replicates a virtually continuous line of strain gauges or thermocouples with just millimeter spacing between sensing points. The fiber can be bonded to a structure in a serpentine pattern to provide a full field mapping of the distribution of strain or temperature. At only 150µm in diameter, the fiber can also be embedded in a structure without influencing the parameters under test.





LEFT: ODiSI enables design validation of composite components

BELOW: Measurement spatial resolution versus sensing length

HD-FOS is ideally suited for designs with high gradients, high uncertainty, lacking in design precedent or where there is insufficient confidence in predictive models. The design of auto components using composite materials falls into these categories and presents engineers with considerable challenges. Unlike metals, composites do not have a homogeneous structure and also lack any great historical data defining variability in manufacturing processes or joining methods.

The challenges facing widespread adoption of composites into the automotive industry are well recognized. The Institute for Advanced Composite Manufacturing Innovation (IACMI) is a public/private partnership funded by the US Department of Energy and focused on overcoming these challenges. Luna Innovations is proud to be a member of the IACMI partnership.

The utility of Luna's ODiSI with HD-FOS measuring capability goes beyond composites and can be used in a number of other challenging test conditions. The Luna ODiSI system has been used to characterize the temperature distribution of clutch plates as well as the strain profiles of windshields. For hybrid and electric vehicles, fiber-optic sensors, given their dielectric and EMI immunity, are perfect for measuring the temperature of a vehicle's battery and inverter, as well as the many printed circuit boards used in an electric vehicle.

Unlike with point-sensing systems, the sensor location, measurement density and gauge length can all be changed dynamically through software and this reconfiguration can be done in minutes rather than the hours it would take to re-instrument with traditional point sensors.

The Luna ODiSI system and HD-FOS technology provide design engineers with unique capabilities to optimize component designs, validate design assumptions and reduce the risk of premature component failure. ‹