Application Note

Fiber Optic Temperature Array Sensors for Cryogenic Processes and Storage Monitoring

The Challenge

The processing of liquefied gases at cryogenic temperatures has been a key discipline for numerous industrial, scientific and medical applications for many decades. For instance, a cryogenic distillation column is used to separate atmospheric air into its primary components such as nitrogen, oxygen, argon and other rare inert gases. Also, fuel gases are often liquefied to produce liquid natural gas (LNG) or liquid petroleum gas (LPG) so as to make their transportation and storage more convenient. More recently, there has been growing interest in the processing of liquid hydrogen (LH2) due to its potential for use as a zero carbon fuel.

Many of these processes rely on very close control of the temperature of the fluids in order to:

- Enable efficient process control
- Increase the output of the process
- Monitor levels of stored liquid gases
- Detect stratification within stored liquid gases
- Create alarms in the event of a leakage

However, there are significant challenges in achieving the number of temperature measurements required to meet this challenge using conventional electrical or electronic sensors due to several factors:

- Limited selection of components with low temperature sensitivity
- Cabling issues (each sensor requires its own cable)
- Electromagnetic interference (EMI) susceptibility
- Safety of use with explosive fluids

So, a different approach is needed.

Fiberoptic temperature sensors based on fiber Bragg grating FBG technology are able to address many of these challenges due to their EMI immunity, dense multiplexing capability with dozens of sensors on a single miniature fiber, and intrinsic safety due to having no electronics at the point of measurement.

Until now, a drawback of using FBG temperature sensors for cryogenic applications is their limited sensitivity at low temperatures. Below 100K, the thermo-optic sensitivity of FBGs to temperature changes quickly diminishes, so that measurement performance at typical LNG temperatures of 80K has been poor, and measurement at LH2 temperatures of 20K has not been possible.

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The Solution

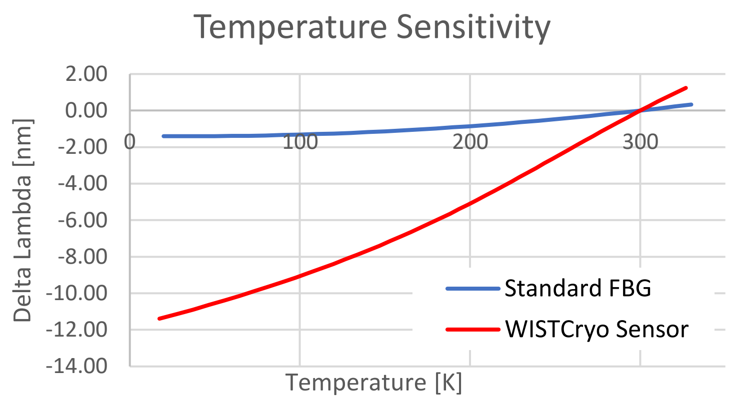
Engineers at Proximion were challenged with developing a variant of their FBG temperature sensing arrays with increased sensitivity and good measurement performance down to 20K and below.

A know approach to this challenge is to substitute the thermo-optic effect which, as described, is negligible at 20K, with the stress-optic effect whereby the thermal expansion of a material attached to or coating the fiber causes measurable changes in strain on the fiber. Candidate materials include metals which are less suitable due to their limited coefficient of thermal expansion at 20K, and polymers which are less suitable due to their poor mechanical performance which leads to poor measurement repeatability and hysteresis.

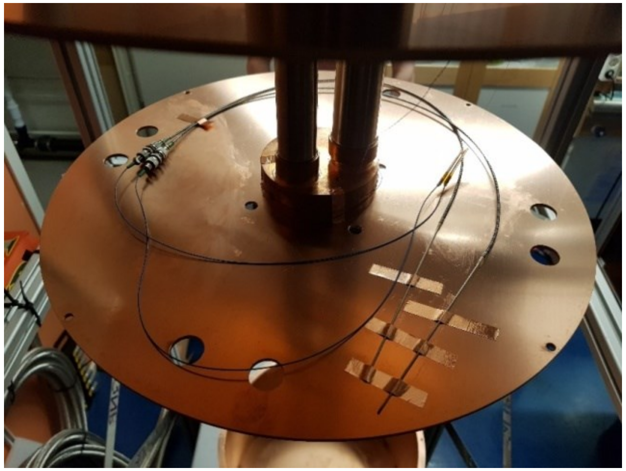
However, using highly honed fiberoptic and materials skills, Proximion engineers have developed WISTCryo, a multiplexed array of FBG temperature sensors that offer excellent measurement performance at cryogenic temperatures down to 20K.

WISTCryo sensor arrays, designed to customer specifications are undergoing trials in numerous industrial applications

A datasheet for WISTCryo is available here.



Showing superior WISTCryo sensitivity vs. a standard FBG sensor



WISTCryo sensor components in a cryostat for testing at 20K.