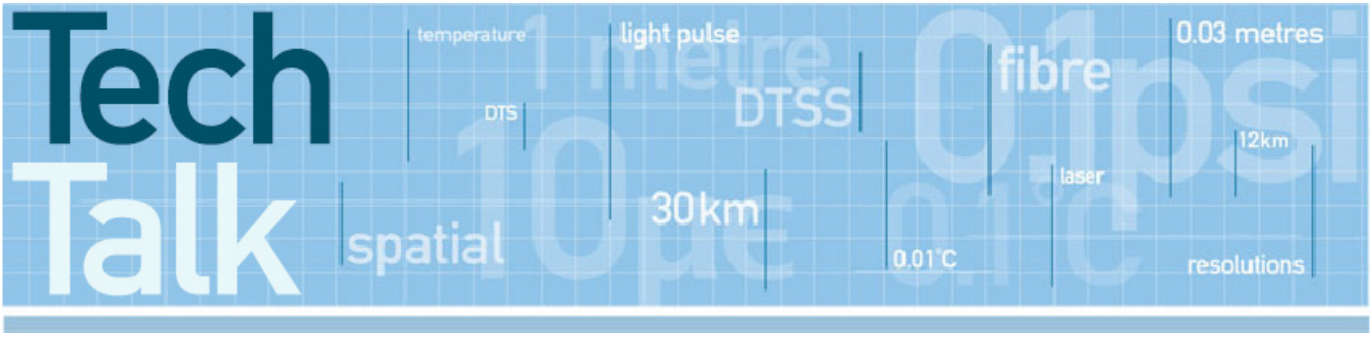
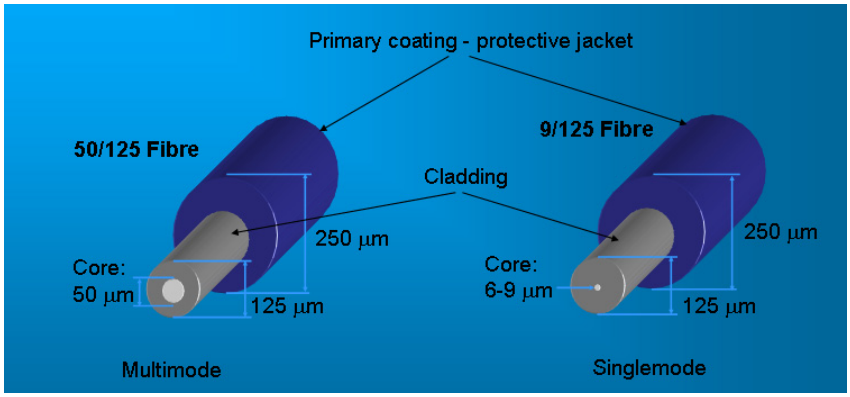


Multimode vs Single Mode Fibre for Distributed Sensing

What is the difference between multimode and singlemode fibre optic?

There are two main different types of optical fibre used– singlemode and multimode fibre (and there are many variants of these).



The light travelling along a fibre can be considered as rays of light that bounce off the interface between the core and the cladding of the fibre. Multimode fibre has a large diameter core which allows the rays of light to travel along several different pathways through the fibre, bouncing at different angles between the core and cladding.

These different pathways are referred to as spatial modes, and hence the description as a *multimode* fibre. Singlemode fiber optic cable has a small core which only allows one path for the rays of light to travel through the fibre, hence the description as a *singlemode* fibre. Multimode fibre typically comes with two different core sizes: 50 micron or 62.5 micron. Singlemode cable features a 9-micron glass core.

Why is multimode fibre used for Temperature sensing?

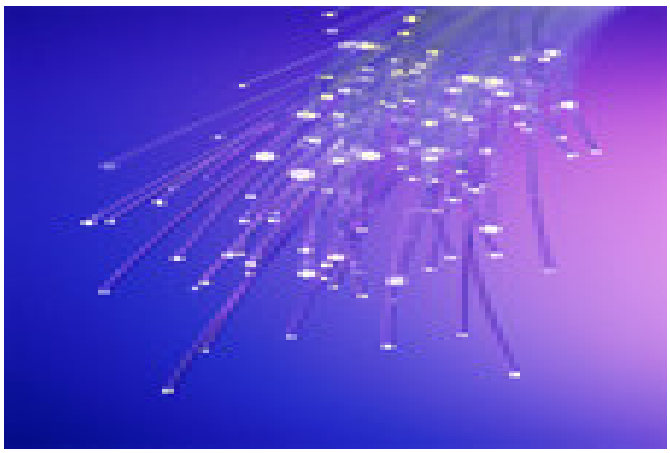
Since multimode fibre has a larger core (and a larger numerical aperture) you are able to launch more power into the fibre than for single mode fibre. The larger core size also results in a higher threshold for nonlinearities, which can cause errors in the measurement of temperature of the fibre. Distributed temperature sensing measures the backscattered light along the fibre. However, the amount of backscattered light is a very tiny proportion of the initial laser pulse and so in order to get enough backscattered signal to make a temperature measurement it is very important to have as much power as possible in the initial laser pulse. Given its larger core size and higher threshold for nonlinearities, multimode fibre provides a large improvement in backscatter signal power over singlemode fibre.

What about for longer sensing distances?

For shorter sensing distances (up to 10 km) the optimum wavelength to use is 1064nm. However the loss in multimode fibre at this wavelength (see table below) means that after 10-12km it becomes very difficult to make temperature measurements. However, if you use a laser with a wavelength of 1550nm the optical loss is lower and so you are able to measure to much longer distances. Although the Sentinel DTS at 1550nm does not have the temperature resolution of the Sentinel DTS that uses 1064nm (0.01°C), once you extend past 10km it becomes advantageous to switch to 1550 nm.

Some DTS systems use singlemode fibre for the longer distances but Sensornet has evaluated this option and found that multimode fibre provides far better temperature resolution since more power can be launched into the multimode fibre than the singlemode fibre. This is true despite the fact that singlemode fibre does offer slightly lower fibre loss at the wavelength of 1550nm.

Fibre Type	Optical Loss/ km @ 1064 nm	Optical Loss/km @ 1550 nm
Multimode	**≈ 1 dB/km**	**≈ 0.3 dB/km**
Singlemode	**≈ 0.7 dB/km**	**≈ 0.2 dB/km**



Why is singlemode fibre used in telecoms over longer distances?

Singlemode fibre is used extensively in telecoms because of the data rates that are involved. Transmission of data using multimode fibre results in something called modal dispersion, arising from the multiple modes. This weakens the transmitted data, limiting the distances over which it can be transmitted. This effect gets worse as you use faster data rates. The DTS only uses a very broad pulse in comparison with telecoms systems, so modal dispersion has a negligible effect on the DTS performance. Singlemode has to be used for telecoms systems where data can be transmitted at multiple Gigabit/s rates over distances of 100's of kilometres. Multimode fibre optic cable can be used for more general fibre applications where the distances are much shorter, such as LAN's.

Why is singlemode fibre used for distributed strain sensing?

Singlemode fibre is used for distributed strain sensing due to the nature of the optical components required. Almost all of the components are standard telecommunications components, designed top operate around a wavelength of 1550nm using singlemode fibre. It is very difficult to use multimode fibre as the sensing fibre if the instrument is based on singlemode components, since a lot of light is lost trying to squeeze the light from the large multimode core into the much smaller singlemode core. The backscatter signal used in strain sensing is more powerful than that used for the temperature sensing, hence the relative lower power of using singlemode fibre can be tolerated.

For more information on Sensornet's range of distributed sensing solutions please contact your local Sensornet representative or e-mail :

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