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# Holographic Enhancement of Fibre Optic Sensors

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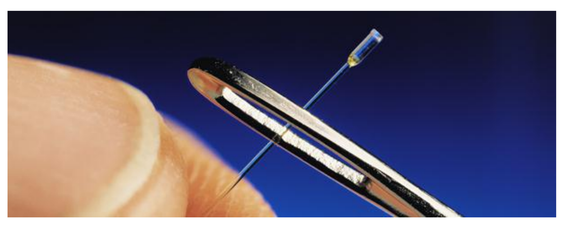
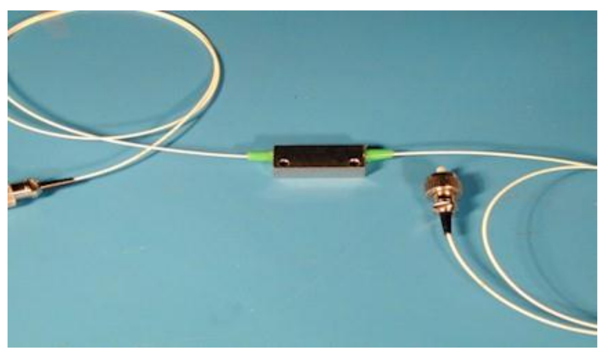
## Introduction



**FIBRE OPTIC SNESORS** are widely available in the market today, used in many industries for various measurands.



Incorporating evanescent field sensing, Surface Plasmon Resonance, fluorescent indicators, or interferometry, they offer a unique set of advantages over conventional electronic sensors

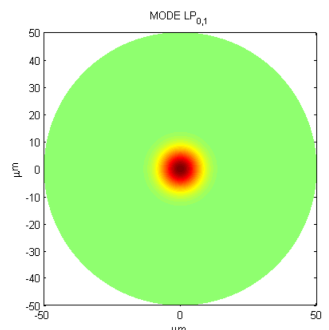
**Advantages**

- Small size
- Light Weight
- Immune to Electro-Magnetic noise
- High temperature performance
- Distributed sensing
- Multiplexing ability

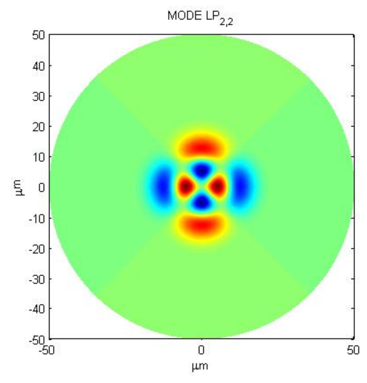
**Common Measurands**

- Temperature
- Strain
- Flow
- pH
- Hydrogen
- High Voltage


## Aims and Objectives

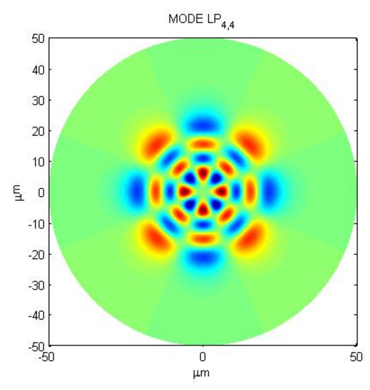


Light propagating through optical fibres does so as a superposition of various Fibre Modes.



Each fibre mode has slightly different properties, such as the propagation constant, mode field diameter, bend losses and susceptibility to mode mixing.

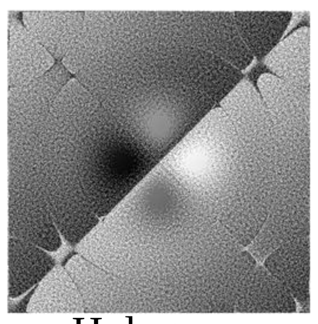
It is therefore expected that various fibre modes will have differing sensing ability.



**The aim of this research is to investigate the performance of Fibre Optic Sensors with the modal composition of light propagating within the fibre, and to improve device performance by controlling the modal excitation.**

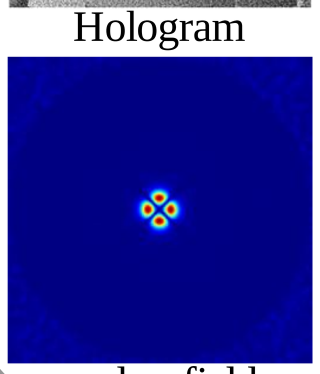
## Holographic Mode Launch

The fibre modes excited when launching light into an optical fibre, depends on the field profile incident on the fibre. Using Holography, a fully controllable replay field can be focused onto the fibre. Therefore, by carefully choosing the hologram, any mode or combination of modes may be excited in the fibre.



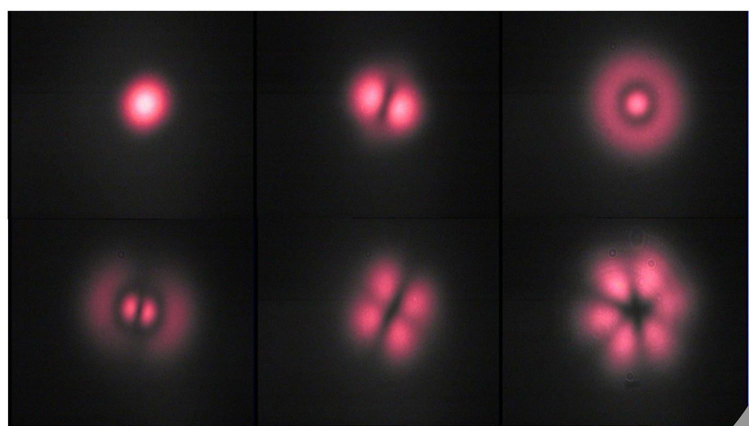
Hologram

Holograms are generated using a Simulated Annealing algorithm which maximises the **Overlap Integral** between the replay field and target mode field.



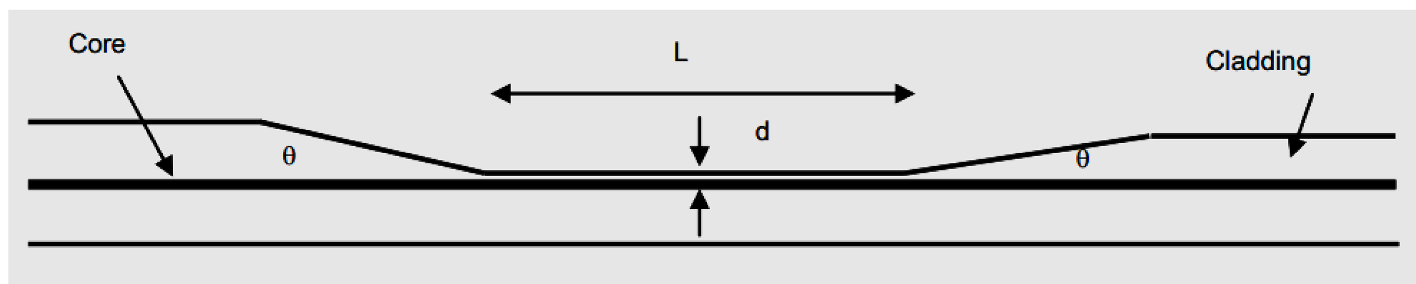
replay field

With different modes launched, images taken at the output of a few mode fibre confirms the mode launch technique used.



## Evanescent Field for Sensing

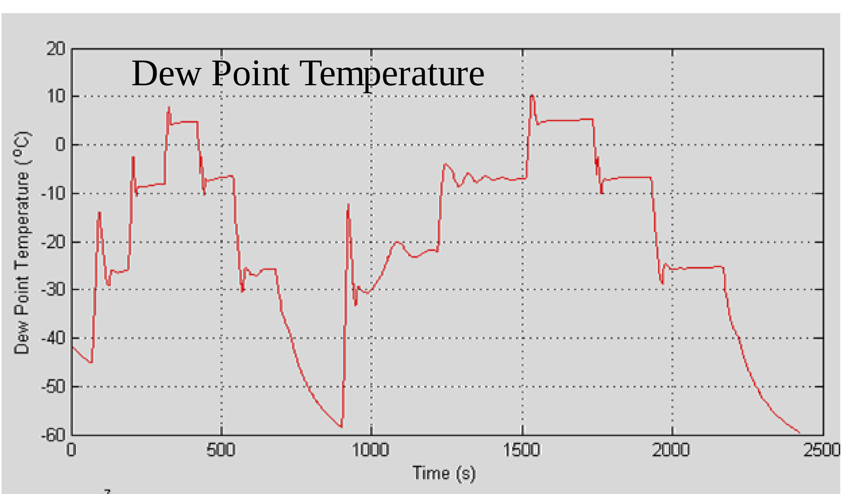
The fibre is made sensitive to humidity by polishing a portion of the cladding away to expose the evanescent field. When the humidity is varied at this sensing region, the change in refractive index with humidity alters the transmission at the polish, resulting in a change in transmitted intensity.

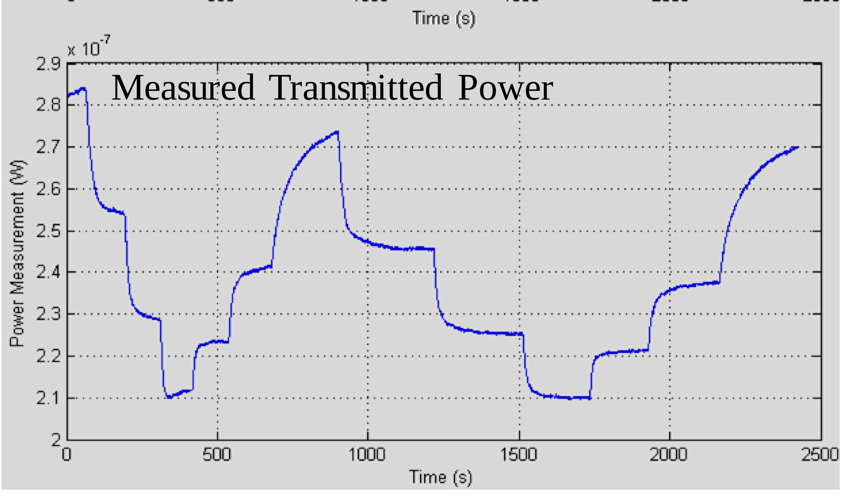



The sensing behaviour is highly dependent on the depth the cladding is polished to. The fibres currently used have large tolerance values on this depth.

This dependence is to be investigated by precision manufacturing the polished region to accurately control the depth.

## Vapour Phase Sensing




Using the polished fibres, humidity sensing is observed by controlling the humidity at the sensing region and measuring the transmitted intensity.

The graphs on the left show the Dew Point Temperature of the controlled humidity and the measured power.

Sensing behaviour is clearly visible with the power measurement having an inverse relationship to the dew point of the sample.

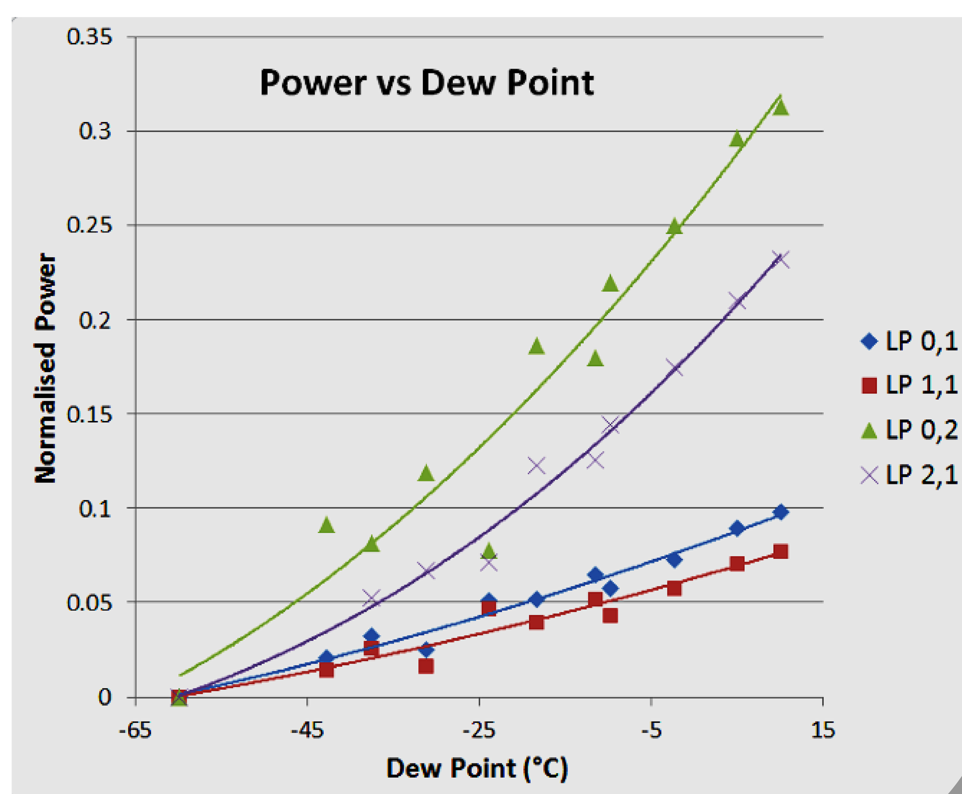
## Modal Sensitivity

To identify the modes which most contribute to sensing, each mode is excited, and the transmitted power plotted against the dew point temperature of the sample.

The graph on the right gives the results of a polished few mode fibre.

The gradient on the graph is related to the sensitivity.

Thus in this device, the $LP_{0,2}$ mode contributes most to sensing. By targeting this mode, the sensitivity of the device can be enhanced.

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