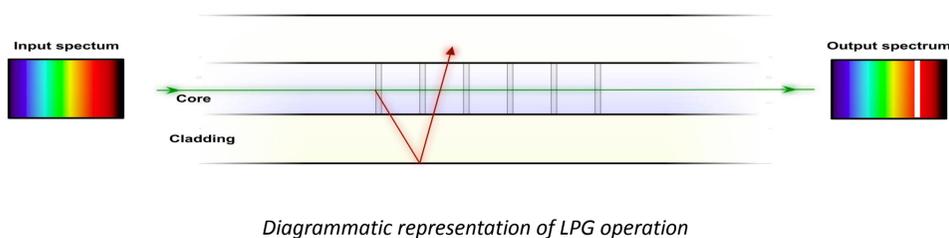


Introduction

Optical fibre long period gratings (LPGs) have been widely exploited as sensing devices. These in-fibre gratings consist of a series of refractive index modulations to the core of the optical fibre, typically with a period between 100 – 1000 μm . LPGs act to couple light from the core to co-propagating cladding modes, resulting in distinct resonance bands in the transmission spectrum.



Using both 1st and 2nd order coupling it is possible to achieve simultaneous measurement of two analytes using a single sensing element [1].

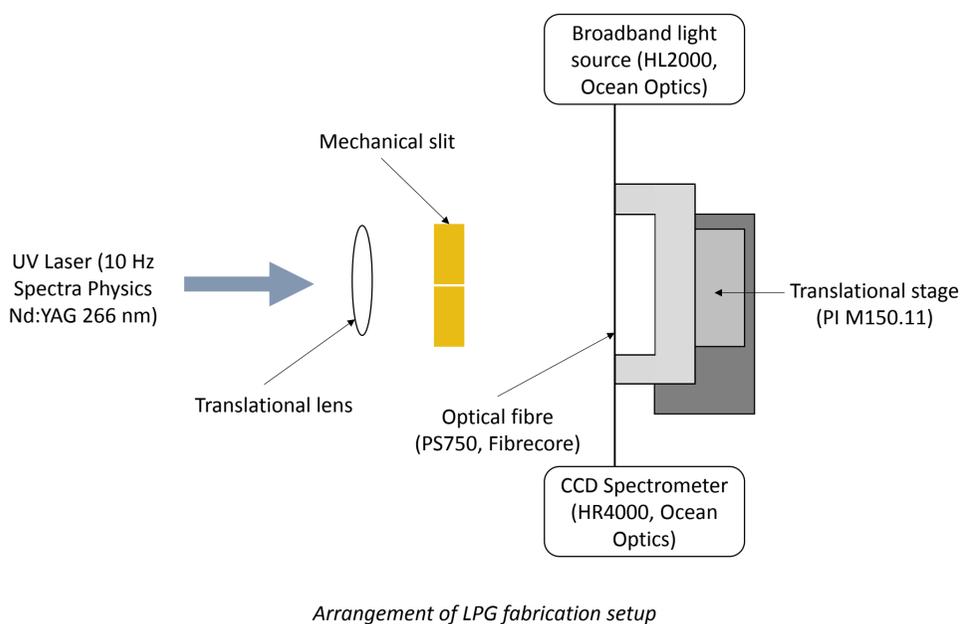
The aim of this research was to demonstrate the fabrication of an LPG showing the resonance bands corresponding to 2nd order coupling at the highly sensitive phase matching turning point (PMPT). Previous work with 2nd order coupling has mainly focused on resonance bands far from the PMPT.

Method

Using numerical modelling a range of appropriate periods were selected.

While numerical modelling can provide an acceptable estimate for PMTP position uncertainties in the fibre characteristics mean that it is not an absolute predictor.

40 mm long LPGs with periods between 167-177 μm were fabricated using the configuration illustrated below using the point-by-point method.



The translation stage moved the fibre by a distance equal to the required periodicity, in unison with the mechanical slit, which opened to half the period, producing a 50:50 duty cycle. This was repeated for the entire 40 mm length.

Each LPG underwent 6 cycles of UV irradiation as outlined in [2] with all obtained spectra analysed using spectrum interrogation software [3].

References

- [1] Allsop, T., Zhang, L., Webb, D. J. & Bennion, I. Opt. Commun. **211**. 2002
- [2] Partridge, M., Barrington, J., James, S. W. & Tatam, R. P. Opt. Express. **24**. 2016
- [3] Partridge <https://dx.doi.org/10.17862/cranfield.rd.3759471>.

Contact details

j.h.barrington@cranfield.ac.uk
Centre for Engineering Photonics
Cranfield University, UK
cranfield.ac.uk



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Poster

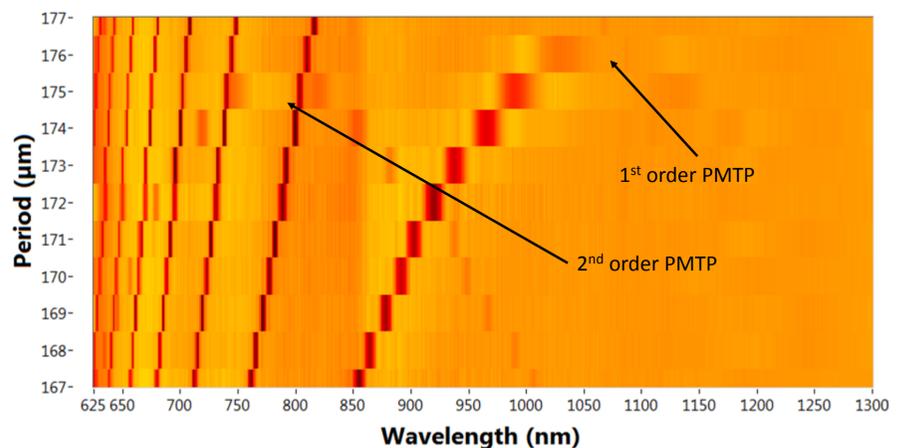


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Data

Results

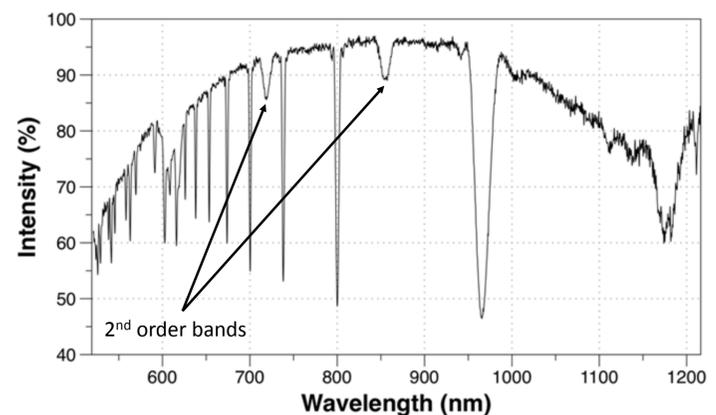
The dark bands in the figure below shows the evolution of the LPG's transmission spectrum with varying period, where 1st and 2nd order coupling PMTP can be observed at centre wavelengths of 1060 and 780 nm respectively.

This means plotting sequential transmission spectra provides a complete description of resonance band evolution, and is ideal for identifying 2nd order features, which typically have an extinction that is lower than that of resonance bands corresponding to 1st order coupling.



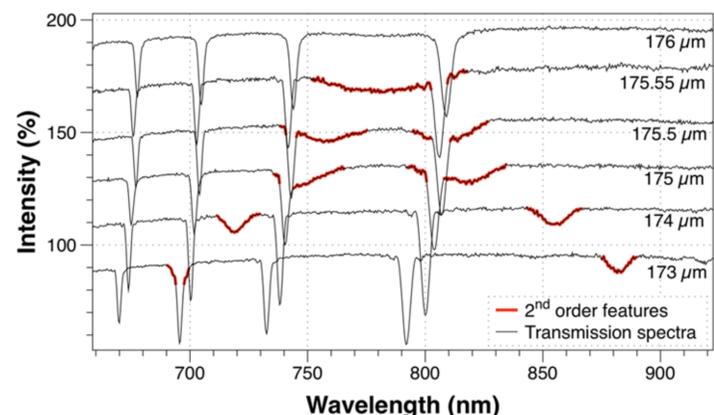
Intensity plot illustrating the relationship between transmission intensity and wavelength at periods between 167 – 177 μm . Yellow and black correspond to 100% and 50% transmission respectively

The lighter bands depict a reduction in extinction characteristic of 2nd order coupling.



Transmission spectrum of an LPG with a period of 174 μm with distinct 2nd coupling order features

As highlighted in the figure below, the 2nd order coupling features can overlap with 1st order coupling bands, creating issues regarding tracking changes in the central wavelengths of the bands.



Transmission spectra of six individual LPGs with periods between 173-176 μm demonstrating the formation of the 2nd order coupling PMPT, shown in the highlighted regions of the spectra

By monitoring the relative intensities of the 1st order features, it is possible to infer the position of the 2nd order band.

Conclusion

- Fabrication of LPGs with 2nd order features operating at the PMTP has been achieved.
- Using intensity plots of sequentially ordered periods and appropriate interrogation methods it is possible for 2nd order bands to be identified and tracked allowing for multi-parameter sensing.