All solid photonic band-gap fibres

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Abstract. We describe the design and fabrication of a photonic bandgap fibre formed using two different glasses. Light is guided in a low-index core region at wavelengths corresponding to the anti-resonances of the high-index strands in the fibre cladding.

1. Introduction

Hollow-core fibres with a photonic bandgap cladding structure formed by a periodic array of air holes in a silica background have attracted great interests in recent years [1,2]. An inverse cladding structure, i.e. isolated high index rods located in low index background, is also interesting, and has previously been studied by filling a silica-air fibre with a high-index liquid [3]. Here we will describe the realization of such a fibre by the use of two thermally matched glasses.

2. Numerical modelling

Fig. 1 shows the structure we are interested in. The band-gap positions in the structure are fixed by the anti-resonance frequencies of each of the high index rods [4], which are determined by the diameter of the rods. The spacing of the rods does not change the band-gap frequencies (to first order) but it does affect the shape of the band-gap, as the result of the change of the coupling strength between rods. Fig 2 clearly illustrates this effect by showing the density of states (DOS) maps of the same size rods being placed at 3 different spacings. In each case, the *y*-axis has been re-scaled as shown at the top of the figure. In Fig. 2 (A), the distance between nearest rods is large compared with the size of the rods, so that the coupling between them is weak. As we move them closer, the band-gap gets narrower and deeper, but its position is fixed around $k_0\Lambda=18$.

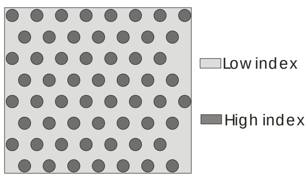

Fig. 1. The cladding structure of all solid photonic band-gap fibre

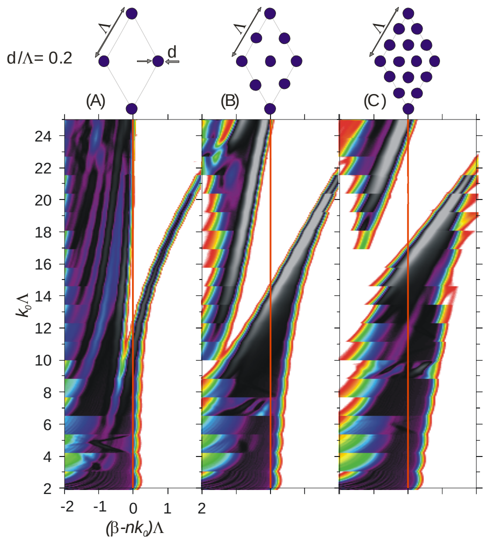

Fig. 2. Density of states plots of the same size rods placed at different distance. The background index was set to 1.54 and the index of rods was 1.79. The red line indicating the line of $\beta=1.54k_0$. The normalisation of the y-axes as illustrated above brings the bandgaps to the same frequencies. The jagged edges on the left-hand side of each plot are at the edges of the computational window.

3. Fabrication

To realize such structure, we use two thermally compatible silicate glasses [5] LLF1 and SF6 from SCHOTT Glass Ltd. LLF1 has an index around 1.55, while the index of SF6 is about 1.79. By using a stacking method we formed the structure shown in Fig 3. The core was formed by replacing 7 SF6 canes by LLF1 canes during the stacking process. Fig 3 was obtained using back scattered electrons in a scanning electron microscope. The white areas are SF6 (higher index) and the dark area is LLF1.

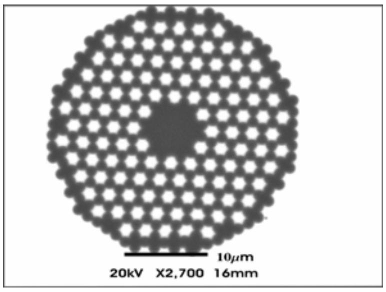

Fig. 3. Back scatting electron image of an all-solid photonic band-gap fibre. The dark shows the LLF1, the white areas are the SF6 rods and jacket.

4. Transmission spectrum

We have observed guidance in the first five bandgaps of the structures. Fig 5. shows a typical transmission spectrum of a fibre, with the second bandgap at a wavelength of around 1μm.

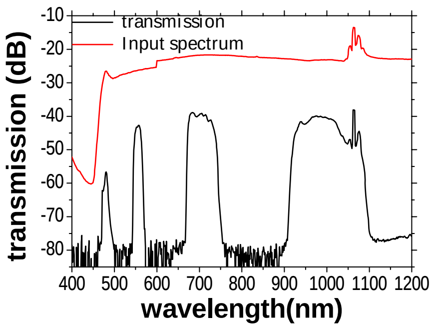

Fig. 5. Typical transmission spectrum of a fibre through 20cm length. The spikes at 1064nm wavelength are the residual pump which was used to form the supercontinuum for the measurement..

5. References

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