Designing Hollow-Core Photonic Bandgap Fibres Free of Surface Modes.

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Hollow-core photonic bandgap fibres (PBGFs) confine light within an air-core due to photonic bandgap effects. Such fibres allow for a very weak overlap between the guided mode and the fibre structure, which paves the way for novel and technologically enabling properties, such as low nonlinearity, high damage thresholds and transmission beyond silica's own transparency window [1]. Mid-IR transmission, not feasible in conventional fibres due to the very high absorption of silica beyond 2µm, has been recently demonstrated in silica PBGFs [2]. However, these fibres had a narrow low-loss operational bandwidth of less than 100nm, due the presence of surface modes (SMs) at their core-cladding interfaces [3]. By systematically studying feasible silica PBGFs core structures we identify new designs regimes that robustly eliminate the presence of surface modes. Optimal fibre designs with a wide transmission spectrum of $\approx 350nm$ centred at $\approx 2\mu m$ are proposed.

We modelled an idealized but realistic representation of a 7-cell core, high air-filling fraction PBGF. The core is defined by a thin non-circular silica ring of nearly constant thickness T_C at the boundary with the cladding as shown in Fig.1. A systematic investigation of the effect of the ring thickness on the fibre's transmission properties was carried out. The normalized boundary thickness (*T*) was varied in the range $0.175 \le T \le 3.5$ and for each fibre we solved for the modes within the bandgap. In order to assess the performance of the fibres we calculated the normalized interface field intensity of the fundamental air-guided mode, factor *F* [4]. This factor suffices to identify designs with broad transmission spectra as its value critically depends on whether or not the fibre supports surface modes.

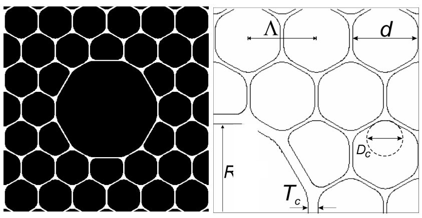

Fig. 1 *Cross section of a modelled PBGF and the parameters used to define the structure.*

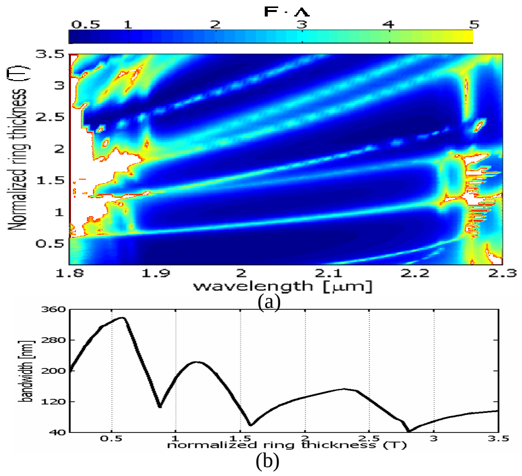

Fig. 2 *(a) F vs. wavelength and normalized ring thickness. (b) Bandwidth of transmission vs T*

Figure 2(a) shows the calculated factor F as a function of *T* and of the wavelength. In this design map, $F\Lambda \le 1$ (blue) denote regions where the FM is tightly confined in the core, and light cyan diagonal lines ($F\Lambda \approx 3$) correspond to anticrossing points between FM and SMs; $F\Lambda \approx 4$ (green) correspond to wavelengths at which the FM is outside the gap, i.e. it coexists with cladding modes; finally, white represents regions where an air guided FM is no longer supported. From the map, we can immediately see that the FM of the fibre with *T*≈0.6 is free of anticrossing for all wavelengths within the gap. For each fibre design, we have estimated the operational bandwidth by setting a threshold value for $F\Lambda \le 1$.The results are presented in Fig.2(b) clearly showing that PBGF structures with rings of thickness in the range $0.45 \le T \le 0.65$ are optimal for broadband transmission, providing a maximum operating bandwidth of ≈350nm at λ=2µm for *T*=0.575.

Conclusions

We have designed a high air filling fraction silica PBGFs with an optimized core design with a wide transmission spectrum of $\approx 350nm$ centred at $\approx 2\mu m$.

References

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