Novel type of hollow-core fiber: hybrid fiber

Fabio Giovanardi[1*], Federico Melli[2], Jonas H Osorio[3], Fetah Benabid[3], Luca Vincetti[2]

1 University of Parma, Department of Engineering and Architecture, Parco Area delle Scienze 181/A, 43124 Parma, Italy
2 University of Modena, Department of Engineering "Enzo Ferrari", Via P. Vivarelli 10, 41125 Modena, Italy
3 GPPMM Group, Xlim Research Institute, CNRS UMR 7252, University of Limoges, Limoges, France

**fabio.giovanardi@unipr.it*

A novel hollow-core fiber design is proposed for obtaining low loss and effective single-mode operation. Promising results are confirmed by theoretical simulations.

Keywords: hollow-core fiber, double cladding, low loss

1. Introduction

In the last two decades, optical fiber technology has seen the advent of a new type of optical fibers named hollow-core photonic crystal fibers (HCPCFs) [1]. HCPCFs can be obtained by exploiting two different waveguiding mechanisms: Photonic Band Gap (PBG) and Inhibited Coupling (IC) [1]. In particular, IC-HCPCFs have proven to be an extremely useful and effective platform for the development of fiber gas lasers [2] and high-power ultrashort-pulse laser beam delivery [3]. IC-HCPCF suffers from confinement loss (CL), thus one of the main research topics in the field is the development of new techniques allowing reducing CL as much as possible.

In this work, we analyze a new kind IC-HCPCFs consisting in a hybrid cladding composed by a tube lattice and a kagome lattice. Numerical results show an impressive reduction of CL partially impaired by the effects of the struts connecting tube to kagome lattice.

2. Theoretical study

The investigated fiber, namely hybrid fiber, is an ideal version composed of kagome fiber (blue part in figure 1) and suspended TLF (red part in figure 1). Although this structure is not achievable, the study can be useful for developing new types of hollow-core fibers.

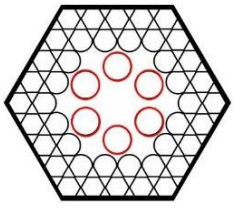
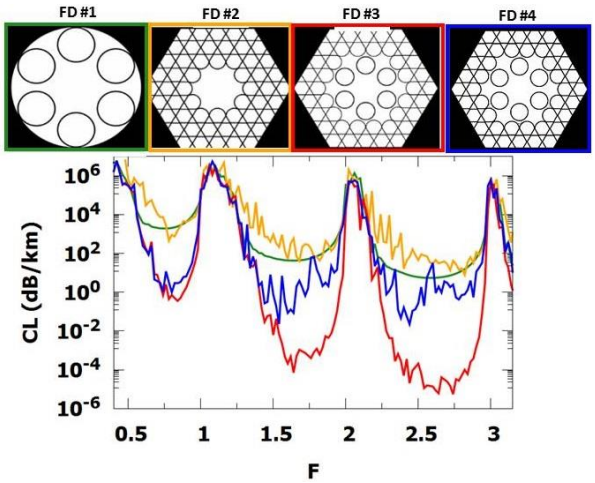


Figure 1 Proposed cross-section of hybrid fiber

In order to estimate the impact of the hybrid cladding, a comparison with other IC-HCPCFs is done. Figure 2 shows the comparison of five relevant designs of fibers: FD#1 is a standard tube lattice fiber, FD#2 is kagome fiber, FD#3 ideal hybrid fiber, and FD#4 hybrid fiber with thin struts connecting tubes to kagome lattice. On the bottom of Figure 2 there is a comparison among the CL of the fibers versus the normalized frequency $F = (\frac{2th}{\lambda})\sqrt{n_{si} - 1}$, where th is the thickness of the silica web, n_{si} the refractive index of the silica, and λ the wavelength. All fibers have the same $th = 1.1\mu m$, and same core diameter of $35\mu m$.

Ideal hybrid cladding guarantees a CL drop ranging from 3 decades in the fundamental band ($F = 0.75$) to 5 decades in the second order band ($F = 2.75$). This dramatic reduction is partially impaired by the negative effects of the struts required to mechanically connect the tubes with kagome lattice. However, the improvement coming from the hybrid cladding is still clear in particular in the fundamental band.



3. Conclusion

Here we have investigated a new kind of IC-HCPCFs based on hybrid cladding. Numerical results show an impressive reduction of CL partially impaired by the effects of the struts mechanically connecting tube to kagome lattice. The proposed approach can open the route to a new kinds of hollow-core fibers based on the combination of different cladding topologies.

References

1. B. Debord et al, Fibers **2,** (2019).
2. F. Aghbolagh et al, Opt. Lett. **2**, (2019).
3. B. Debord et al, Opt. Express **22**, (204).