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Hybrid photonic bandgap effect in twisted hollow-core photonic bandgap fibers: supplement

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This document provides supplementary information to "Hybrid photonic bandgap effect in twisted hollow-core photonic bandgap fibers". The supplement material is organized as follows. In section 1, we calculate the confinement losses in different orthogonal polarizations. The result shows that there is no obvious loss difference between the two orthogonal polarizations. In section 2, we calculate the dispersion curves, losses, and HOMERs of vectorial modes. The differences between them are negligible, so the description through LP modes is sufficient in this case. © 2022 Optica Publishing Group

1. Confinement losses in different orthogonal polarizations

The 7-cell hollow-core photonic bandgap fiber (HC-PBF) with a triangular lattice of air-holes cladding and an approximately regular rounded dodecagon core has C_{6v} rather than C_{4v} symmetry structure [1]. Therefore, the two fundamental modes (FMs) with orthogonal polarizations, namely FM_x and FM_y, have slightly different mode characteristics, including electric field distribution and loss. However, in most cases, this slight difference could be negligible.

The confinement loss (CL) spectra of FMs with $\alpha = 0, 4, 8$ rad/mm in x and y polarizations are shown in Fig. S1. The CL spectra of FM_x and FM_y are almost the same. Therefore, the CL spectra of only one polarization LP01 mode with $\alpha = 0, 1, ..., 10$ rad/mm are shown in Fig. 5 of the main text.
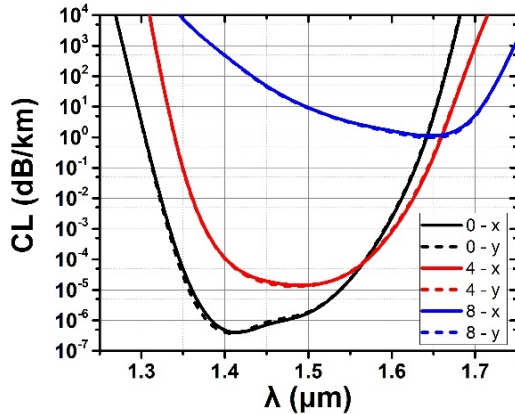

Fig. S1. CL spectra of FM_x and FM_y with $\alpha = 0, 4, 8$ rad/mm.

2. Dispersion curves, losses, and HOMERs of vectorial modes

The 7-cell HC-PBF is a slightly multimode fiber, which has four relatively low-loss higher-order modes (HOMs): TM01, HE21e, HE21o, and TE01 modes. These four vectorial modes with similar dispersion curves, loss, and electric field distribution are usually degenerate to the four-fold degenerate LP11 modes [2].

If the vectorial modes are considered, Figs. 4 and 7 in the main text are replotted to the following Figs. S2 and S3. According to Fig. S2, the dispersion curves for the TM01, HE21e, HE21o, and TE01 modes of the 7-cell HC-PBF are almost overlapped each other. Hence, they have similar N_{eff} and transmission characteristics in different λ. Furthermore, the HOM extinction ratio (HOMER) and losses of TM01, HE21e, HE21o, and TE01 modes on α are also similar as shown in the Fig. S3. Therefore, it is sufficient to use LP11 modes to represent the four vectorial modes because they have similar dispersion curves, losses, and HOMERs.
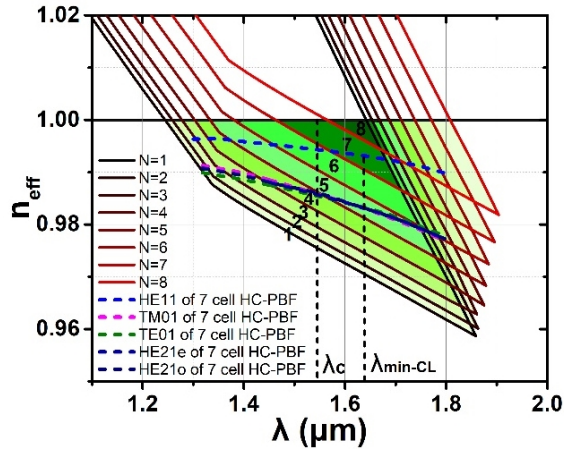
Fig. S2. Schematic of the hybrid photonic bandgap of a twisted HC-PBF with α = 6.5 rad/mm. The dashed lines are the dispersion curves for the HE11, TM01, HE21e, HE21o, and TE01 modes of the 7-cell HC-PBF.
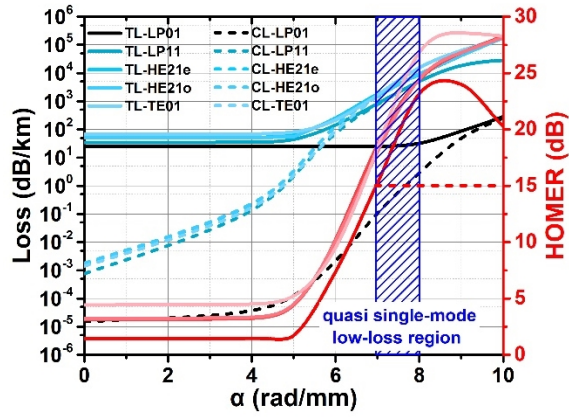

Fig. S3. Calculated dependences of HOMER and losses of HE01, TM01, HE21e, HE21o, and TE01 modes on α for the twisted 7-cell HC-PBFs.

Supplementary References

1. Y. Zhu, N. Song, F. Gao, and X. Xu, Opt. Express **29**, 30371 (2021).
2. K. Zamani Aghaie, V. Dangui, M. J. F. Digonnet, S. Fan, and G. S. Kino, IEEE J. Quantum Electron. 45, 1192 (2009).