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Design of a hollow-core microstructured optical fiber with low loss and high polarization-maintaining

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Abstract

In this paper, a hollow-core microstructured optical fiber with low loss and high polarization-maintaining (HPBG-HCARF) is proposed. By adding several rounded hexagonal air-hole arrays to the cladding of the hollow-core polarization-maintaining fiber, the requirements of low loss and high polarization-maintaining are achieved. In the wavelength ranges of 1.540 μm-1.585 μm and 1.609 μm-1.653 μm, the confinement loss is less than 0.1 dB/km, and the birefringence is higher than 5×10^{-5}. Such a fiber performance heralds new opportunities for hollow-core anti-resonant fibers in practical applications.

Results

1. Design of the HPBG -HCARF

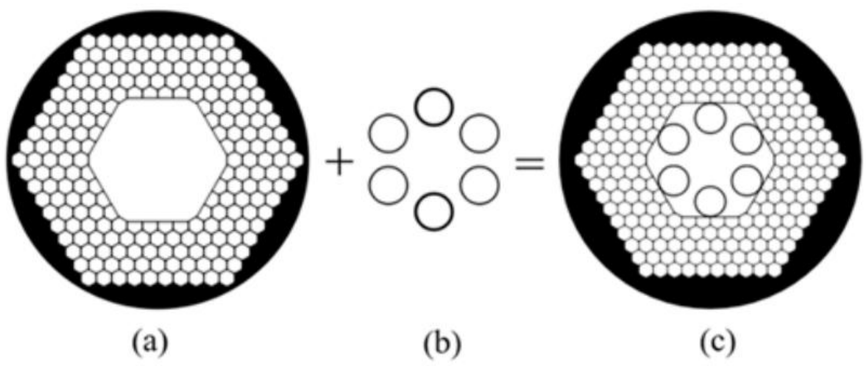

Fig. 1. Design model of the HPBG-HCARF.
(a) The 61-hole hollow-core photonic bandgap fiber; (b) Six capillaries; (c) HPBG-HCARF.

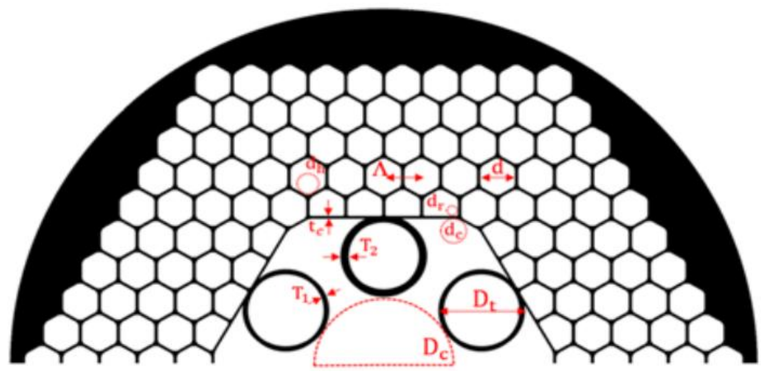

Fig. 2. Structural parameters of the HPBG-HCARF.

- The six capillaries are embedded in the air core of the hollow-core photonic bandgap fiber. The thickness of two capillaries in the vertical direction is not consistent with that of the other four capillaries to introduce high birefringence in the HPBG-HCARF.
- In order to achieve low loss transmission in the range of 1300 nm to 1600 nm, the bandgap structure parameters are set to the following fixed values: Λ=4.7 μm, d=0.98Λ, d_h=0.44Λ, d_c=0.94Λ, d_r=0.2Λ, t_c=0.5(Λ-d). The diameter of the six capillaries is fixed proportional to the size of the air core, D_t=0.6D_c. By combining the structure parameters of bandgap and deriving the geometric structure relationship, D_c and D_t are approximately 17.365 μm and 10.419 μm, respectively.

2. Numerical simulation and analysis

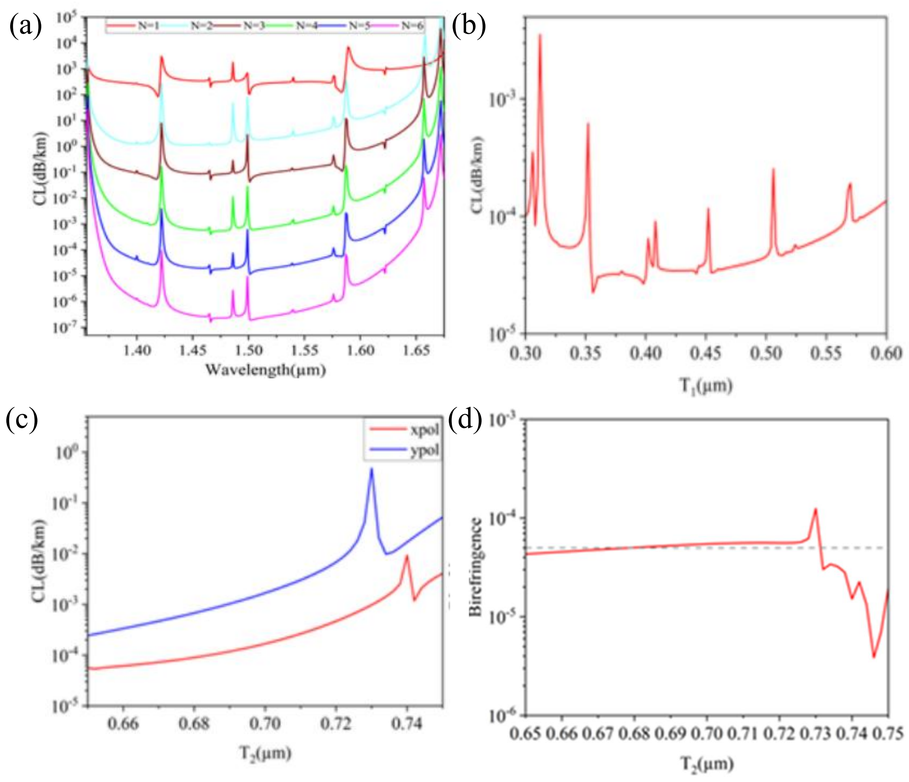

Fig. 3. Confinement loss spectrum of (a)different number of bandgap layers; (b)different T_1; (c) different T_2; (d) birefringence of the HPBG-HCARF,

- When the number of bandgap layers reaches 5 or more, the confinement loss in the range of 1.355 μm to 1.65 μm is less than 1 dB/km. To consider the power limitation ability to light, N=5 is selected as the best parameter of this structure.
- The most appropriate values of capillary thickness T_1 and T_2 are explored according to the principle of the conventional resonant band in the polarization-maintaining hollow-core anti-resonant fiber. Firstly, set T_2=T_1 to determine the area of low confinement loss. The first-order anti-resonant thickness is 0.372 μm calculated from the anti-resonant condition, which corresponds to the low loss region of Figure 3(b).
- In order to narrow the range of thickness variation, the first-order resonant thickness is about 0.744 μm. Increasing the calculation range from 0.650 μm to 0.750 μm can ensure that the thickness in both directions is within the first-order anti-resonant thickness area.
- With the increase of T_2, the confinement loss increases gradually, while the birefringence increases gradually and then decreases. When the value of T_2 increases towards the first-order resonant region, the fundamental mode will leak along this direction, resulting in increased loss and changes in birefringence. When the size of T_2 is between 0.680 μm and 0.710 μm, it shows a low confinement loss and high birefringence greater than 5×10^{-5}.

Conclusion

- A hollow-core microstructured optical fiber with low loss and high polarization-maintaining is presented theoretically.
- The structure parameters of the optical fiber are optimized, including the number of bandgap layer N, the thickness of the inner capillary T_1 and T_2.
- The confinement loss and birefringence of the optimized optical fiber show that in the wavelength ranges of 1.540 μm-1.585 μm and 1.609 μm-1.653 μm, the confinement loss is less than 0.1 dB/km, and the birefringence is higher than 5×10^{-5}.

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