INTERNATIONAL CONFERENCE ON NONLINEAR OPTICS AND NOVEL MATERIALS

SIMULATED INFLUENCE OF TEMPERATURE AND TOTAL DIAMETER ON NEAR- ZERO-DISPERSION BAND OF SUSPENDED CORE FIBER WITH WATER

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ABSTRACT:

In this paper we present the simulated dispersion characteristics of the three bridges suspended crystal fiber consists of BK7 glass and holes fulfilled with water. The stable dispersion band and near zero-dispersion band are analyzed. For broadening and optimization the zero-dispersion band we analyze the influence of temperature of water and structure parameters on dispersion characteristics.

Keywords: suspended core fiber, zero-dispersion wavelength, quasi-zero-dispersion band.

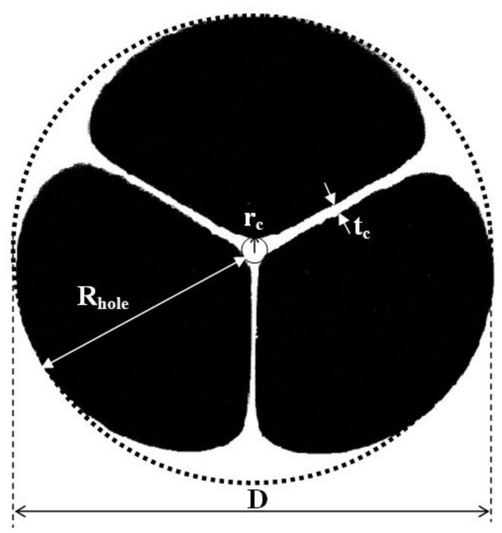
I. INTRODUCTION

Since small core and high NA, the suspended-core fiber (SCF) has the strong nonlinear and dispersion properties [1, 2]. SCFs are continuously improved for different nonlinear applications. Up to now, the most important applications are soliton self-frequency shift [3], third-harmonic generation[4], Raman wavelength shift [5], Optical Parametric Oscillator, supercontinuum generation [5,6], ...

As shown in many works, to expand SCF's application in different fields it is necessary to change the chromatic dispersion and nonlinear characteristics. There are many works already addressed the dispersion engineering of SCFs [7-9], but paid attentions to the thorough analysis of the influence of all the cross-section parameters on the fiber properties. Particularly, the influence of the number, thickness of the glass bridges, and diameter of the core on the zero dispersion is investigated [10]. It is real that the dispersion properties are usually related not to the mentioned parameters only, but to the kind of glass and temperature of medium fulfilling the holes. To perfect the dispersion properties of SCF, the aim of this paper is to numerically investigate the zero dispersion of three bridges BK7 SCF with holes fulfilled with air and water, particularly, influence of temperature of the water and total diameter on the stable dispersion and near -zero dispersion bands which one of SCF guiding properties.

II. DETAIL OF NUMERICAL MODING OF THE FIELDS AT THE FIBER OUTPUT

we consider a three bridges BK7 SCF with three holes fulfilled with water (or air), its cross section is described with structure parameters in Fig.1.



The refractive index of BK7 glass has been calculated according to the Sellmeier equation [12]:

$$n_{BK7}^2(\lambda) = 1 + \frac{B_1\lambda^2}{\lambda^2 - C_1} + \frac{B_2\lambda^2}{\lambda^2 - C_2} + \frac{B_3\lambda^2}{\lambda^2 - C_3}$$

where constant coefficients are given in Tab.1.

Glass	B_1	B_2	B_3	C_1(µm²)	C_2(µm²)	C_3(µm²)
BK7	1.0396	0.23179	1.0104	0.00600069867	0.0200179144	103.560653

The refractive index of water is a function of optical wavelength, temperature and pressure is given as follows [13]:

$$\begin{aligned} n_W(\lambda, T, p) = \sqrt{\frac{a_1}{\lambda^2 - \lambda_a^2} + a_2 + a_3\lambda^2 + a_4\lambda^4 + a_5\lambda^6} \\ + \left(b_1 + b_2\lambda^2 + b_3\lambda^4\right)(T - T_b) \\ + \left(b_4 + b_5\lambda^2 + b_6\lambda^4\right)(T - T_b)^2 \\ + \left(b_7 + b_8\lambda^2 + b_9\lambda^4\right)(T - T_b)^3 \\ + \left[c_1 + c_2\lambda^2 + \left(c_3 + c_4\lambda^2\right)T\right](p - p_b) \\ + \left(c_5 + c_6\lambda^2\right)(p - p_b)^2 \end{aligned}$$

with the range of validity of $0.228 \le \lambda \le 2.770\mu m$, $-10^oC \le T < 100^oC$, $1bar < p < 120bar$

where the values of all constant coefficients $p_b = 1.0133bar$, $T_b = 19.996^oC \approx 20^oC$, $\lambda_a = 0.01\mu m$ can be taken from [13].

A key parameter that describes properties of fibers is a group velocity dispersion (GVD). It is defined by the dispersion parameter [14]:

$$D(\lambda) = \frac{\lambda}{c}\frac{d^2 n_{eff}}{d\lambda^2}$$

where n_{eff} is the effective refraction index $n_{eff} = \frac{\beta(\lambda, n(\lambda))}{k_0}$

III. TUNNING OF ZDW WITH TEMPERATURE AND TOTAL DIAMETER

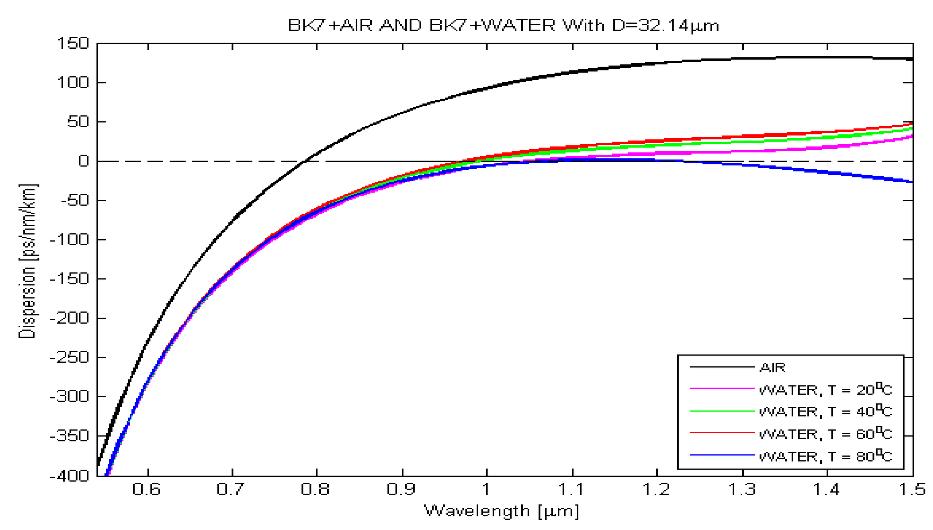
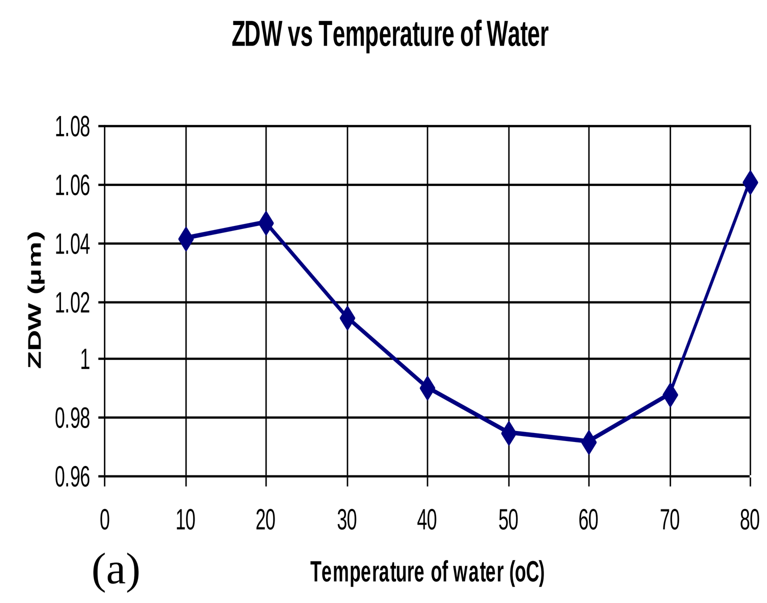
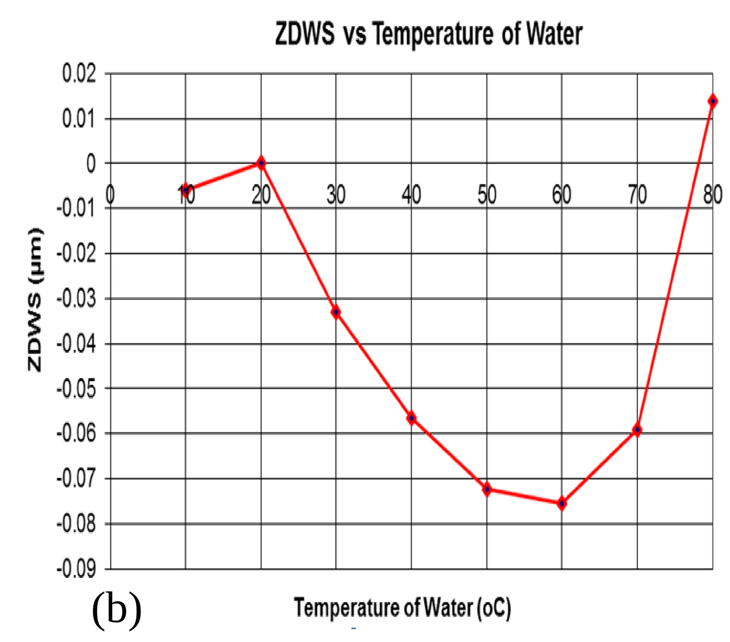


Fig.2 Dispersion characteristics with different temperature of water with total diameter of 32.14µm.



(a)



(b)

Fig.3 Dependence of ZDW (a) and ZDWS (b) on temperature of water.

Firstly, using FEM we study the dispersion properties of three bridges BK7-SCF with total diameter of 32.14 µm (that means radius of holes of 15.23 µm, radius of core of 0.82µm, and thickness of bridges of 0.25µm). The dispersion characteristics of BK7-SCF with air holes and holes fulfilled water at different temperature of water 20, 40, 60 and 80°C are presented in Fig.2.

The results in Fig.2 we can see that i) The ZDW is blue shifted about 300nm when the air-holes are replaced by water-holes; ii) The ZDW nonlinearly depends on temperature of water (Fig.3a), so the relative to 20°C ZDWS is always blue shifted untill T>78°C (Fig.3b).

IV. STALBE AND NEAR ZERO DISPERSION BANDS OF SCF

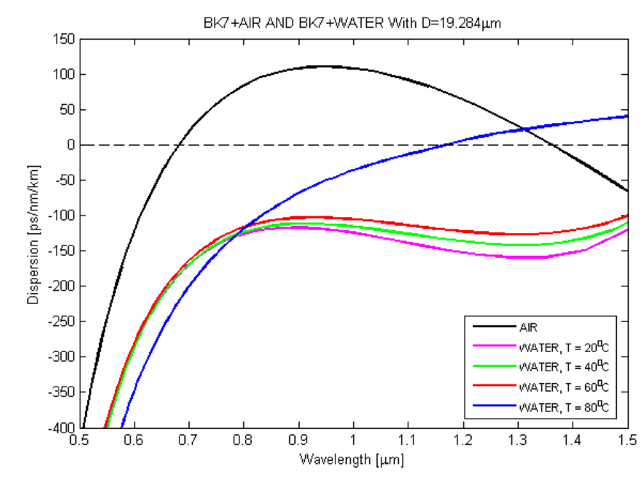


Fig.4 Dispersion characteristics with different temperature of water with total diameter of 19.284µm.

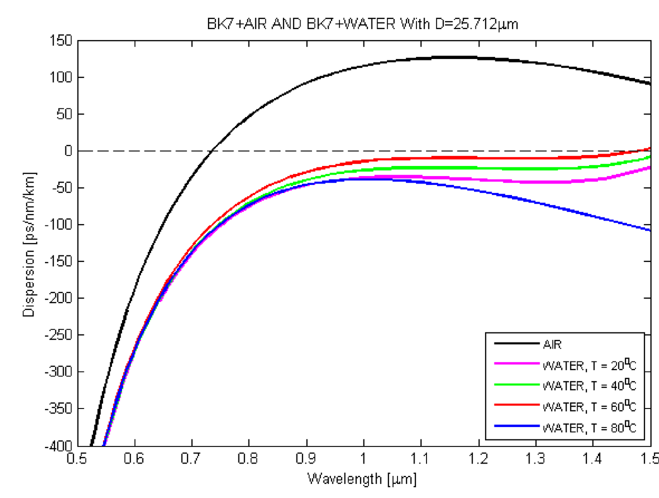


Fig.5 Dispersion characteristics with different temperature of water with total diameter of 25.712µm.

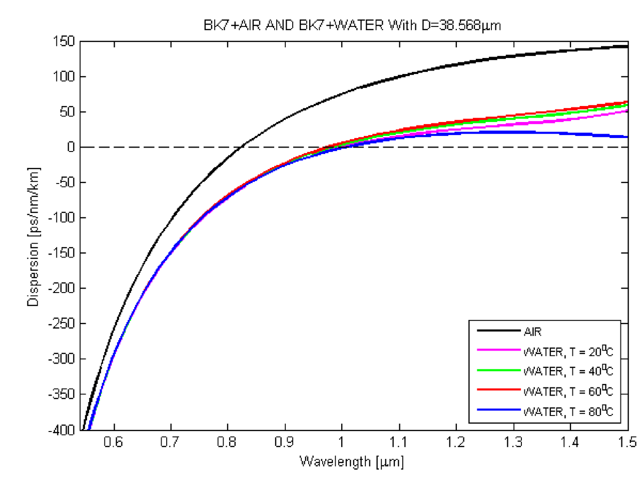


Fig.6 Dispersion characteristics with different temperature of water with total diameter of 38.568µm.

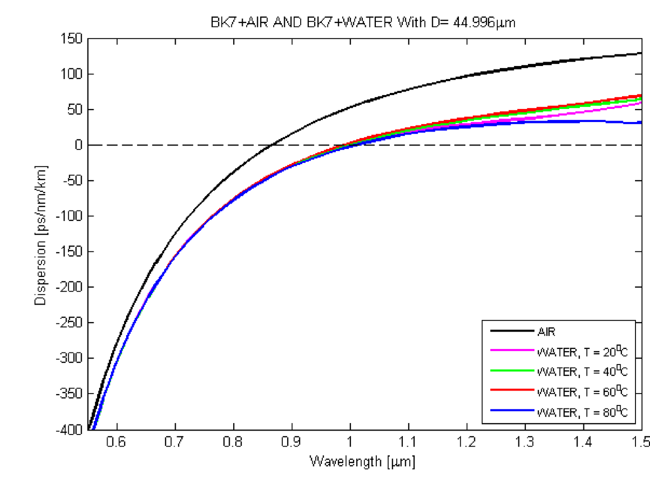


Fig.7 Dispersion characteristics with different temperature of water with total diameter of 44.996µm.

V. CONCLUSIONS

We have simulated the dispersion properties of the three bridges BK7 SCF with air-holes and water-holes. The results show that zero dispersion wavelength can be tuned over 300 nm when the air-holes are replaced by water-holes. A change of water temperature in the range 10÷80 °C allows dynamic shifts of the ZDW and the ZDWS is always blue shifted untill T>78°C. A three bridges BK7 SCF with suitable structure parameters and holes fulfilled with water kept at suitable temperature, particularly at 20°C, will have a stable dispersion band or near zero dispersion band.

Therefore, if we consider optical fiber network using three bridges SCF with water-holes where the large optical stable or zero dispersion bands are needed, this can be achieved by choice the suitable structure parameters and temperature of water.

VI. REFERENCES

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