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Chromatic dispersion in fiber optic with ordered rotating of glass microstructure (ORGM)

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This paper study the chromatic dispersion of optical fiber with ordered rotating of glass microstructure(ORGM), with specific recipe of core and cladding in the fourth window of transparency ($\lambda = 1.562$ up to 1.622 micron), and a quantitative evaluation of dispersion changes in optical fiber with(ORGM) compared with isotropic dispersion of optical fiber is agents. The calculation of chromatic dispersion of optical fiber with (ORGM) was carried out.

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1. Introduction

Most components of optical fiber system of transfer using the Anisotropic media, such as polaroids, controlled directional couplers, light modulators, optical fibers and other components whose the operating principles are based on optical Anisotropy.

The problem of increasing the volume of information and improving its quality over the optical fiber system is associated with a significant improvement for all parameters and components of optical fiber system, specially the transmission parameters of fiber optic as signal dispersion. and it is possible to solve this problem with using optical fiber that having the anisotropic media.

It is known in [1,2,3,5,6,7] that to construct an optical fiber with anisotropic properties, we must put it in an external electromagnetic field or creating an internal mechanical stress in the fiber. Such mechanical stress makes the structure of the glass molecules ordered.

The photo elastic properties of the curved optical fiber are described by dielectric permittivity tensor, where the tensor elements can be obtained from the expressions that depend on the parameters of spiral form characterizations [1].

In [4] it was analyzed the elements of dielectric permeability tensor of anisotropic optical fiber twisted by spiral, depending on the parameters that characterizing the shape of the spiral. and in [2,4] it was obtained an expression that define the chromatic dispersion of optical fiber with ordered rotating of glass microstructure (ORGM), but it was a qualitative analysis, however a quantitative evaluation of chromatic dispersion in the optical fiber was not made.

The purpose of this paper is to study the chromatic dispersion in fiber optic with ordered rotating of glass microstructure (ORGM) with specific recipe of core and cladding in the fourth window of transparency ($\lambda = 1.562$ up to 1.622 micron), where in the transmission parameters are investigated in a lesser extent than in the other windows of transparency, and a quantitative evaluation of dispersion changes in optical fiber with(ORGM) compared with isotropic dispersion of optical fiber is agents.

2. Method and procedure

Carry out the calculation of chromatic dispersion of optical fiber with (ORGM), where the core is made from pure quartz (SiO_2) and the cladding is doped (3%) of boron oxide (B_2O_3).

The total chromatic dispersion D_T of optical fiber with (ORGM) is defined by [2,10]:

$$D_T = (1 + D_m) D_s \ , \tag{1}$$

Where $D_m = \frac{\pi . r_1}{p}(\sin\varphi + \cos\varphi) = D_m^o + D_m^e$, (2)

the material dispersion
Where p -step of spiral.

r_1- radius of a circular beam of HE_{11} mode spot in straight isotropic optical fiber[5,8,9].
Indices “e” and “o” in equation (2), refer to the extraordinary and ordinary waves.
D_s- chromatic dispersion of straight isotropic optical fiber which given in [6] as:

$$D_s = \Delta\omega \frac{\partial^2}{\partial\omega^2}\left[\frac{\beta_{10}}{\varepsilon(r)}\right] \tag{3}$$

Where β_{10}-the phase coefficient of the lowest mode HE_{11} in optical fiber.
$\varepsilon(r)$- the permittivity of straight isotropic optical fiber.
Thus, from (1) follows that the total chromatic dispersion in optical fiber with ORGM) differ from chromatic

dispersion of straight isotropic optical fiber by increment ΔD which equal:

$$\Delta D = D_m . D_s \tag{4}$$

The specific chromatic dispersion of straight isotropic fiber D_s is the sum of specific material dispersion D_m and waveguide dispersion D_w [3]:

$$D_s = D_m + D_w = \frac{\lambda}{c} . \frac{d^2 n}{d\lambda^2} + \frac{N\Delta}{\lambda . c} . \nu . \frac{d^2(\nu b)}{d\nu^2} \tag{5}$$

Where n and N are the refractive index and group refractive index of core and cladding.

Δ - relative refractive index difference of core and cladding which equal: $\Delta = \frac{n_1 - n_2}{n_1}$

λ - wave length.

c - light speed.

ν - normalized frequency.

b - normalized phase coefficient.

To determine the chromatic dispersion of straight isotropic optical fiber D_s,we must determine the refractive indices for core and cladding (n and N).so the calculation result of refractive indices for core and cladding in the range of wavelengths corresponding to the fourth window of transparency are presented on the Fig. 1.

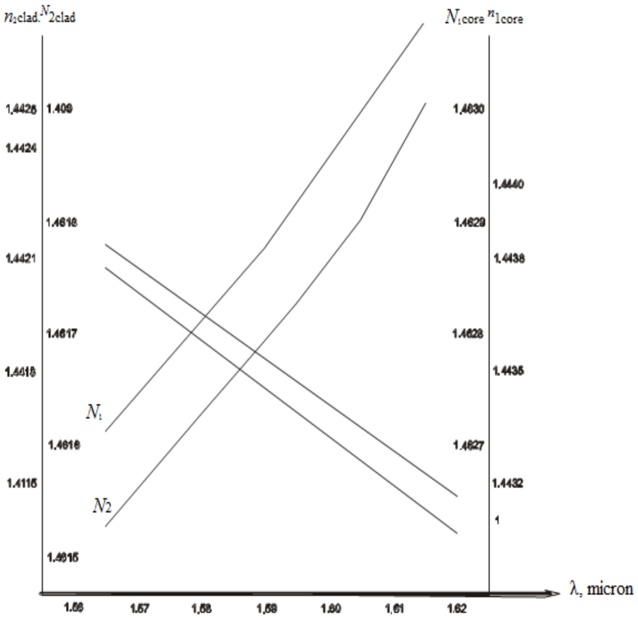

Fig. 1. Spectral dependence of nN *for core and cladding.*

Using the above expressions for determining the refractive indices of core and cladding, it was calculated the density of material dispersion of core $D_{m(core)}$ and cladding $D_{m(cladding)}$ and the graphs of spectral density dependence of material dispersion are shown on Fig. 2.

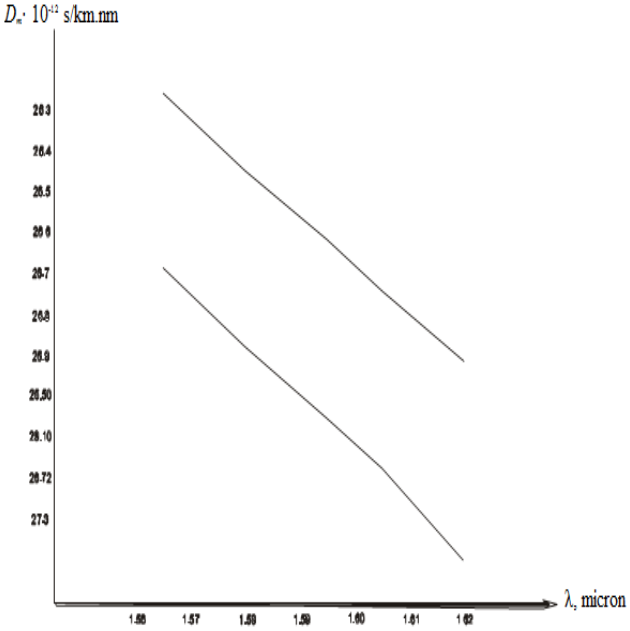

Fig. 2. Spectral dependence of D_m *for core and cladding.*

From calculations follow that the specific material dispersion of core and cladding are negative and modified accordingly in the range of (-26.25 to -26.69 ps/km for the wavelength 1.565 micron) up to (-26.91 to -27.35 ps/km for the wavelength 1.62 micron).using the second term of expression (5), which define the specific waveguide dispersion $D_{waveguide}$ for straight isotropic optical fiber,it was calculated the $D_{waveguide}$ for the core in the same wavelength range while the second factor in the expression for calculation $D_{waveguide}$determined according to the schedule [[3], Fig. 10 [8]] for step index profile and the graph of specific waveguide dispersion for the core depending on the wavelength shown on Fig. 3.

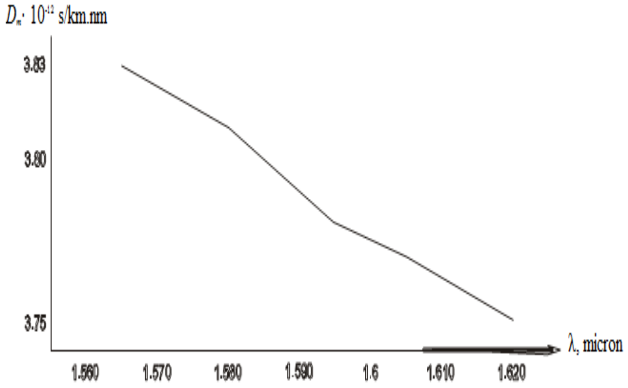

Fig. 3. Spectral dependence of D_m of straight isotropic optical fiber.

3. Result and discussion

From Fig. 3, it is clear that with increasing the wavelength the specific waveguide dispersion decreases from 3.83 to3.75 ps/km in the investigated range of wavelengths 1.565 and 1.62 micron.

The chromatic dispersion of straight isotropic optical fiber D_s in the wavelength range (1.565 to 1.62 micron) which representing the sum of D_m and D_w is represented on Fig. 4. And as can be seen from Fig. 4, the value of specific chromatic dispersion of straight curved fiber varies from (-22.4 ps/km.nm for the wavelength 1.565 micron) to (-23.17 ps/km.nm for the wavelength 1.62 micron).

To determine the increment ΔD of straight curved fiber due to the ordering of microstructure in optical fiber,it was calculated the parameter D_m and also defined the ΔD itself in the azimuthally Coordinate range φ ,which changes from (0^0 to 360^0) and thus the radius r_1 accepted to be equal 3 micron and the step of spiral p = 50 mm.

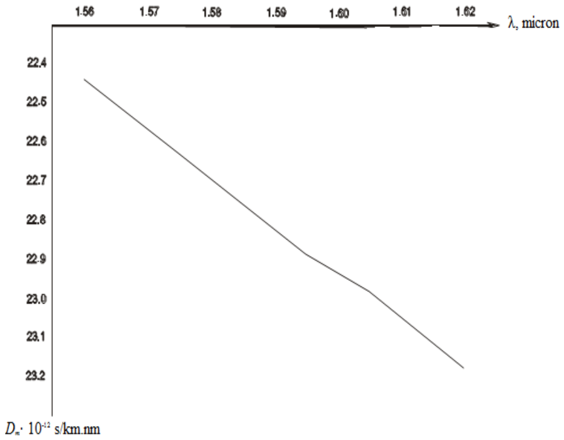

Fig. 4. Spectral dependence of chromatic dispersion for straight isotropic optical fiber.

The result of D_m and ΔD calculations are given in Table 1 .

Table 1. Azimuthally dependence of D_m and ΔD .

φ ,degree	D_m , ps/km.nm	$\Delta D.10^{-4}$, ps/km.nm
0	1.885	42.25
15	2.308	52.75
30	2.595	59.27
45	2.665	60.87
60	2.595	59.27
75	2.308	52.72
90	1.885	42.25
105	1.333	30.46
120	0.87	19.87
135	0	0
150	-0.87	-19.87
165	-1.333	-30.46
180	-1.885	-42.25
195	-2.308	-52.72
210	-2.595	-59.27
225	-2.665	-60.87
240	-2.595	-59.27
255	-2.308	-52.72
270	-1.885	-42.25
285	-1.333	-30.46
300	-0.87	-19.87
315	0	0
330	0.87	19.87
345	1.333	30.46
360	1.885	42.25

The graph of amplitude dependence ΔD shown on Fig. 5, and this figure show that in the range from ($\varphi = 0^0$ to $\varphi = 135^0$ and from $\varphi = 315^0$ to $\varphi = 360^0$) the value of ΔD is positive. but in the range from ($\varphi = 150^0$ to $\varphi = 300^0$) the value of ΔD is negative.

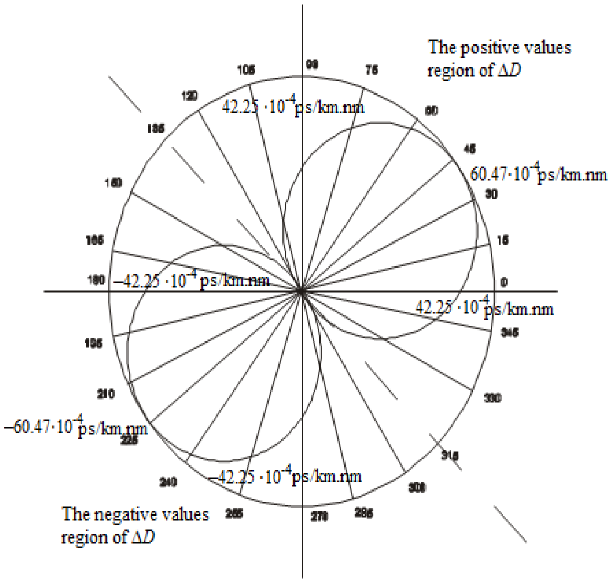

Fig. 5. Amplitude dependence of ΔD.

4. Conclusion

We can conclude that the studying of chromatic dispersion in optical fiber with ORGM in the fourth window of transparency show that the chromatic dispersion of such fiber compared with isotropic dispersion of optical fiber changes by a few tenths of percentage. However the change of chromatic dispersion in this case is depend strongly on the azimuthally coordinate of observation point. Such azimuthally dependence of chromatic dispersion in optical fiber with ORGM comparing with isotropic can be used in the designing process of optical fiber cables to create a compensators of polarized dispersion in single mode optical fiber which are used in the coherent optical fiber system of transfer. As well as in the students educational process.

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