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مطالعهٔ تأثیر فیبرهای کریستال فوتونی با چینش های متفاوت بر پروفایل شدت خروجی

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دانشکدهٔ فیزیک، دانشگاه اراک

چکیده – در این پژوهش ، اثرات تغییر در آرایش فیبرهای کریستال فوتونی بر پروفایل شدت خروجی به ازای طول موج های پر کاربرد مخابراتی بررسی شده است .به منظور مطالعهٔ پروفایل ها ، یک تابع گوسی بر پروفایل های شدت خروجی حاصله با دقت بسیار خوبی فیت شده است . نتایج نشان می دهند در حالی که مقادیر ۰.۴ و ۴ به ترتیب برای پارامتر کسرپرشدگی و تعداد حلقه های هوا انتخاب شده اند ، افزایش تعداد ضلع در ناحیهٔ غلاف نه تنها منجر به افزایش شدت خروجی می شود بلکه پهنای نیمهٔ ماکزیمم را نیز کاهش می دهد .

کلید واژه – پهنای نیمهٔ ماکزیمم ، تابع گوسی ، شدت خروجی ،فیبرهای کریستال فوتونی با چینش های متفاوت

The Study of the Influence of PCFs with Various Configurations on Output Intensity Profiles

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Abstract: In this study, effects of variation in photonic crystal fibres′ (PCFs) configuration on output intensity profiles were investigated for three significant telecomm wavelengths. In order to study the profiles , a Gaussian function was fitted on all obtained profiles with good agreement . The achievements show that while the amounts of air filling fraction and number of air rings were $d/\Lambda = 0.4$ and $N=4$, respectively , increasing the number of edges in cladding region can not only rise the central intensity but also it can decrease the full width at half maximum (FWHM).

Keywords**:** central intensity, full width at half maximum, Gaussian function, photonic crystal fibre′s with various configuration

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1 Introduction

Photonic crystal fibres (PCFs) classified according to their cores into micro – structured fibres (MOFs) or holey fibres (HFs) are an innovative class of fibres with unique properties [1]. In comparison with conventional fibres, the preference of PCFs is the ability of altering the effective index by altering the diameter of air holes (d) or the constant lattice (Λ) in cladding region or sometimes via doping the core region.

In recent simulations, researchers have often tried to concentrate on only common arrangements of air hole in cladding region and examined one or two specific configurations like square and hexagonal designs [2, 3]. Moreover, in order to improve the facility of these fibres, researchers have sometimes made such assumptions as offering several different amounts for the diameter of air holes or constant lattice at the same air rings [4, 5] but it seems that these unique designs can be beneficial only under supposed conditions and fabricating these PCFs may be uneconomical or very difficult. However, in this study, the effect of various configurations of PCFs including six distinctive structures which commence from square – lattice and carried on a PCF with Nano – lattice are investigated on the output intensity profiles. The significance of this study appears especially in medical applications like optical coherence tomography (OCT) imagining [6].

In order to examine the output profiles, both the central intensity and the width of profiles are found and discussed.

2 Results and discussions

In order to illustrate the effects of various arrangements of air holes in the cladding region which result in PCFs with different configurations, we commence our simulations from a PCF with square-lattice and carry on up to a PCF with Nano structure. It should be mentioned that in all supposed configurations, other effective parameters like the diameter of air holes (d) as well as the number of air rings (N) are kept constant so that it provides the possibility of merely inspecting the effect of variation in the PCFs′ structure on their performances.

The importance of employed wavelength in this study reveals in medical problems because for instance, the OCT dentistry imagining is performed at λ = 1.35μm [7].

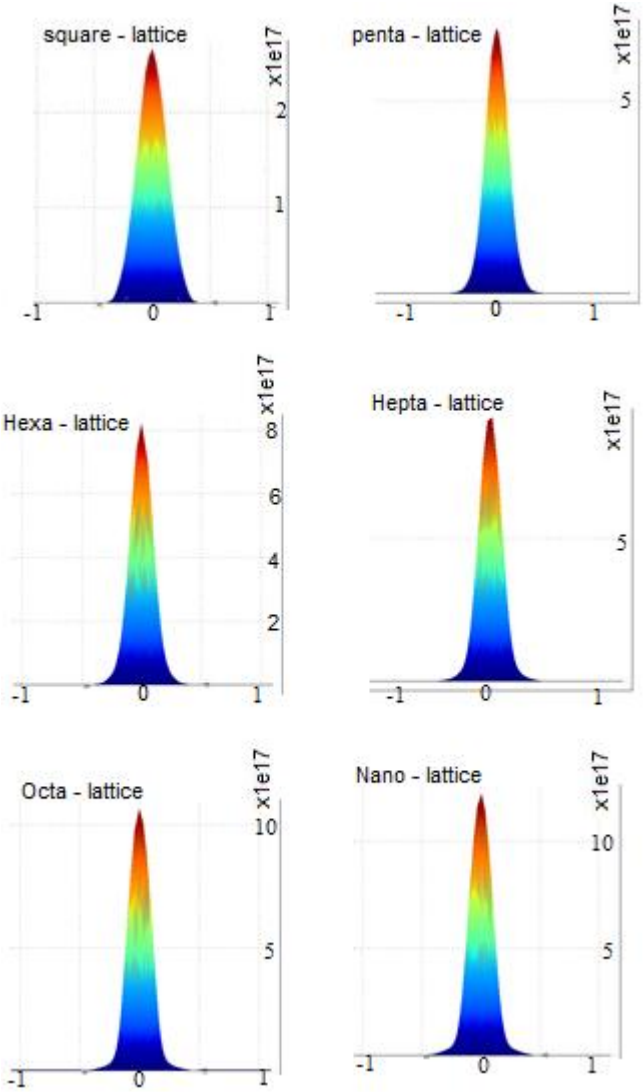


Fig .1 The actual output intensity profiles related to various configurations while d/Λ = 0.4, N= 4 and λ=1.35μm

In this case, the OriginPro software is employed to analysis and to approximate the output profiles obtained by the COMSOL software and to find the

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appropriate function which is very close to the actual profiles. In order to have a rigorous investigation of the profiles, a Gaussian function is used to fit to the obtained actual intensity profiles. The proposed function is defined by Equation (1):

$$f(x) = I_o\, e^{\frac{-(x-x_\circ)^2}{2w^2}} \qquad (1)$$

Where I_o signifies to the central intensity and w is the standard deviation also, x_o can be any value that is very small and can be ignored.

The errors reported by the OriginPro software which are involved with the approximation are presented in table 1. The accuracy of the proposed function can be verified by the fact that the ratio of the standard errors reported via the software to the actual amount of central intensity is so trifling and can be ignored (see table 1) .To study the width of profiles , another useful parameter – full width at half maximum(FWHM) – is obtained by the software .

Table 1. The values of the central intensity and FWHM when d/Λ=0.4 , λ = 1.35μm and N=4

structures	central intensity $(w/m^2)x10^{17}$	FWHM (μm)
Square-lattice	2.676±0.031	4.034±0.062
Penta - lattice	7.024±0.100	3.301±0.056
Hexa - lattice	8.006±0.006	2.971±0.027
Hepta - lattice	9.068±0.072	2.732±0.028
Octa - lattice	11.082±0.152	2.899±0.049
Nano - lattice	12.039±0.131	2.061±0.027

In Fig.2, the approximated profiles which related to the considered PCFs and are obtained by using the software are depicted. Moreover, in Figs .3 and 4, the plots of central intensity and FWHM as a function of the number of edges are shown, respectively (d/Λ= 0.4, N= 4 and λ = 1.35μm).

According to these figures, it is obvious that increasing the number of edges in cladding region can not only boost the central intensity considerably but also it can decrease the FWHM parameter.

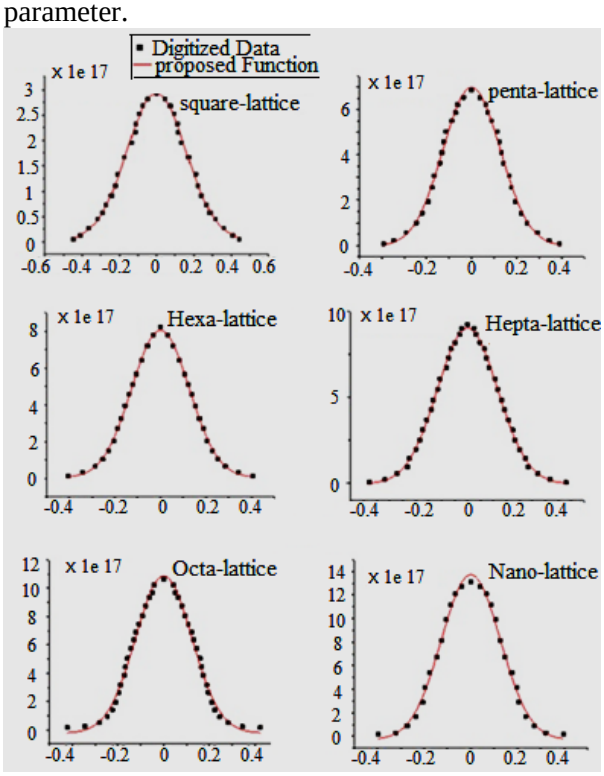


Fig. 2 Approximated output intensity profiles belonged to various configurations while d/Λ= 0.4, N = 4 and λ = 1.35μm (the actual profiles are shown in Fig.1)

As can be seen in Fig.2, the proposed function is fitted on the actual profiles with good agreement because the digitized data and the employed function coincide completely.

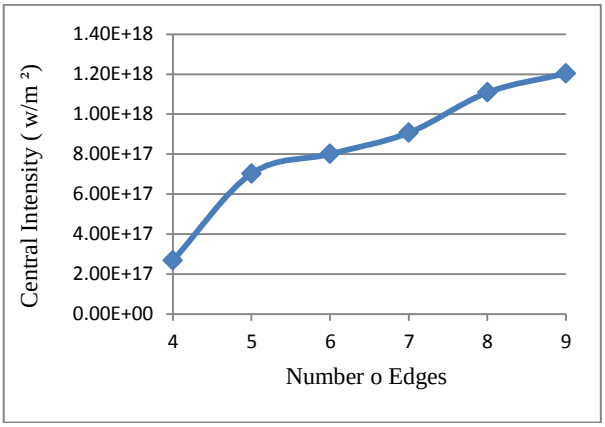


Fig. 3 Plots of central intensity against the number of edges (d/Λ = 0.4, N= 4, λ= 1.35μm)

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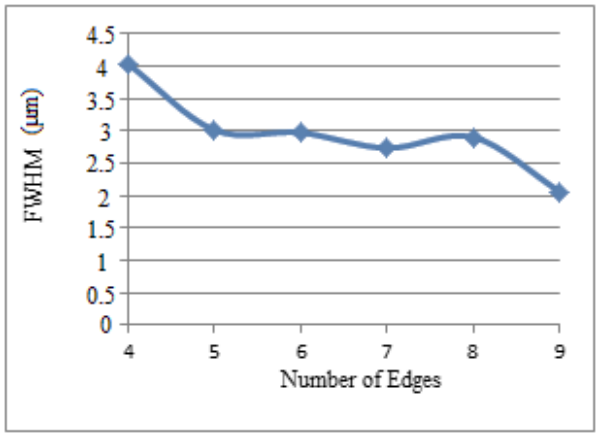


Fig. 4 Plots of FWHM against the number of edges (d/Λ = 0.4, N= 4, λ= 1.35µm)

The results in Fig.3 show that a marked increment can be seen in the central intensity plot when the number of edges in the cladding is increased from the PCF with square-lattice to the PCF with Nano structure. Also, according to Fig.4, the PCF with Nano-lattice reduces the parameter FWHM to 2µm which is a noticeable decrease in this parameter.

Comparing our results with other works [3], cannot be carried out exactly, since they have used special arrangements for their optical fiber (only a PCF with hexa-lattice) and has mainly focused on investigating the influence of variation in the parameter d/Λ on the field distribution of the fundamental mode in this fiber.

3 Conclusion

In this research , the influence of the variation in the PCFs' configuration (from square – lattice to a PCF with Nano – lattice) on the delivery intensity (output intensity profiles) are studied while other effective parameters like d/Λ and N as well as the employed wavelength are kept constant .

A Gaussian function is used to fit on the output profiles which coincide thoroughly too digitized data obtained of the actual intensity profiles. In order to investigate the output profiles closely, the plots of the central intensity ($I_{o)}$ and the full width at half maximum (FWHM) as a function of the number of edges are depicted .

The achievements show the rise in the number of edges in cladding region can not only boost the central intensity but also it can decrease the FWHM parameter. Consequently, the increment in the number of edges (to a PCF with Nano – lattice) provides the opportunity of the best delivery intensity under supposed conditions (d/Λ = 0.4)

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