



Waveguiding properties of a $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ large mode area fiber with an octagonal cladding

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ABSTRACT

Solid-core optical fibers with a large core structure ($D_c = 4\lambda - d$) generally provide a large effective mode area, offering potential for a wide range of photonic applications. In this work, an octagonal $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ -based photonic crystal fiber is proposed and numerically analyzed, in which the large core region is obtained through the omission of first layer of air holes surrounding the center. The data results indicate that the proposed design maintains a relatively large effective mode area, approximately $10 - 100 \mu\text{m}^2$ over the range of $1 - 10 \mu\text{m}$. In addition, in the $1 - 7 \mu\text{m}$ region, an ultra-low confinement loss with an average magnitude of about $10 - 8 \text{ dB/m}$ is achieved. These properties indicate the potential applicability of the proposed photonic crystal fiber in high power transmission, nonlinear optics, and mid-infrared photonic systems.

1. INTRODUCTION

Small core photonic crystal fibers (PCFs), with core diameters typically below $5 \mu\text{m}$, typically possess strong optical nonlinearity, making them highly advantageous for broadband supercontinuum generation (SCG). However, their small core size drastically increases local optical intensity, which limits power handling, enhances long-wavelength loss, and makes efficient mode matching with laser sources or other large core fibers more difficult. In addition, the large output beam divergence and the potential onset of multimode operation further restrict their suitability for high power applications and practical optical systems. Consequently, small core PCFs are often less suitable for SCG requiring high spectral power in areas such as nonlinear bioimaging, light detection and ranging systems (Van et al., 2023; Genty et al., 2005; Shen et al., 2018).

To address this issue, photonic crystal fibers with large mode areas (LMA-PCFs) have been widely investigated for high power SCG. In general, the term LMA-PCF refers to photonic crystal fibers specifically designed to provide a significantly larger effective mode area than conventional PCFs through an enlarged core region. With effective mode areas ranging from tens to several hundreds, and even up to thousands of μm^2 , these designs enable higher optical power transmission while preserving low loss and good beam quality. Although widely used as a fiber material, silica-based PCFs still exhibit several limitations for SCG. Due to the relatively low Kerr nonlinearity of silica, high power SCG typically requires either longer fiber lengths or higher pump powers. In addition, the transparency window of silica is limited to around $2.4 \mu\text{m}$, which restricts further spectral extension into the mid-infrared (mid-IR) region (Jiang et al., 2015). A further challenge is that increasing the mode area to achieve LMA operation makes it more difficult to simultaneously maintain single mode behavior, effective mode confinement, and low confinement loss, mainly due to increased bending loss in large core structures. Thus, LMA-PCF using silica materials often requires stringent design conditions (Ademgil & Haxha, 2012). The aforementioned limitations have driven the trend of researching non-silica materials, especially chalcogenides, to exploit their higher nonlinearity and efficient transmission in the mid-IR band for biomedical and gas sensing due to the molecular fingerprint

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region (Genty et al., 2005; Van et al., 2025; Ren et al., 2019; Yi et al., 2013). Among chalcogenide glasses, Ge-Sb-S systems show a Kerr nonlinearity that is hundreds to thousands of times greater than that of silica (Eggleton et al., 2011). In addition, their wide transmission window, covering from nearly 1 μm to beyond 12 μm , makes them highly favorable for enhancing nonlinear optical effects in LMA-PCFs. Furthermore, many studies have successfully fabricated PCFs using standard melt-quenching techniques (Yi et al., 2013; Choi et al., 2016; Shang et al., 2021; Liu et al., 2009). However, current studies on chalcogenide PCFs have mainly focused on Ge-Sb-Se and As-based glass systems, while PCF based on $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ glass, particularly for LMA designs, have not yet been reported, although several related studies have demonstrated SCG performance in PCFs employing similar host materials (Shahriar et al., 2023; Medjouri & Abed, 2019). Therefore, investigating LMA-PCF based on this material is crucial for optimizing optical properties and developing high power, broadband SCG sources that operate efficiently in the mid-infrared region.

In this study, octagonal LMA-PCFs based on $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ glass are proposed and numerically investigated to evaluate their optical guiding characteristics in the mid-IR region. By optimizing the microstructured geometry, the proposed fibers are able to maintain large effective mode areas ranging from 10 to 100 μm^2 together with ultra-low confinement loss over the 1 – 7 μm range. These characteristics are highly beneficial for broadband and high power SCG, particularly for applications requiring strong mid-IR spectral intensity in the molecular fingerprint region, such as nonlinear optical processing, biomedical imaging, and gas sensing.

2. LMA-PCF DESIGN AND THEORETICAL MODEL

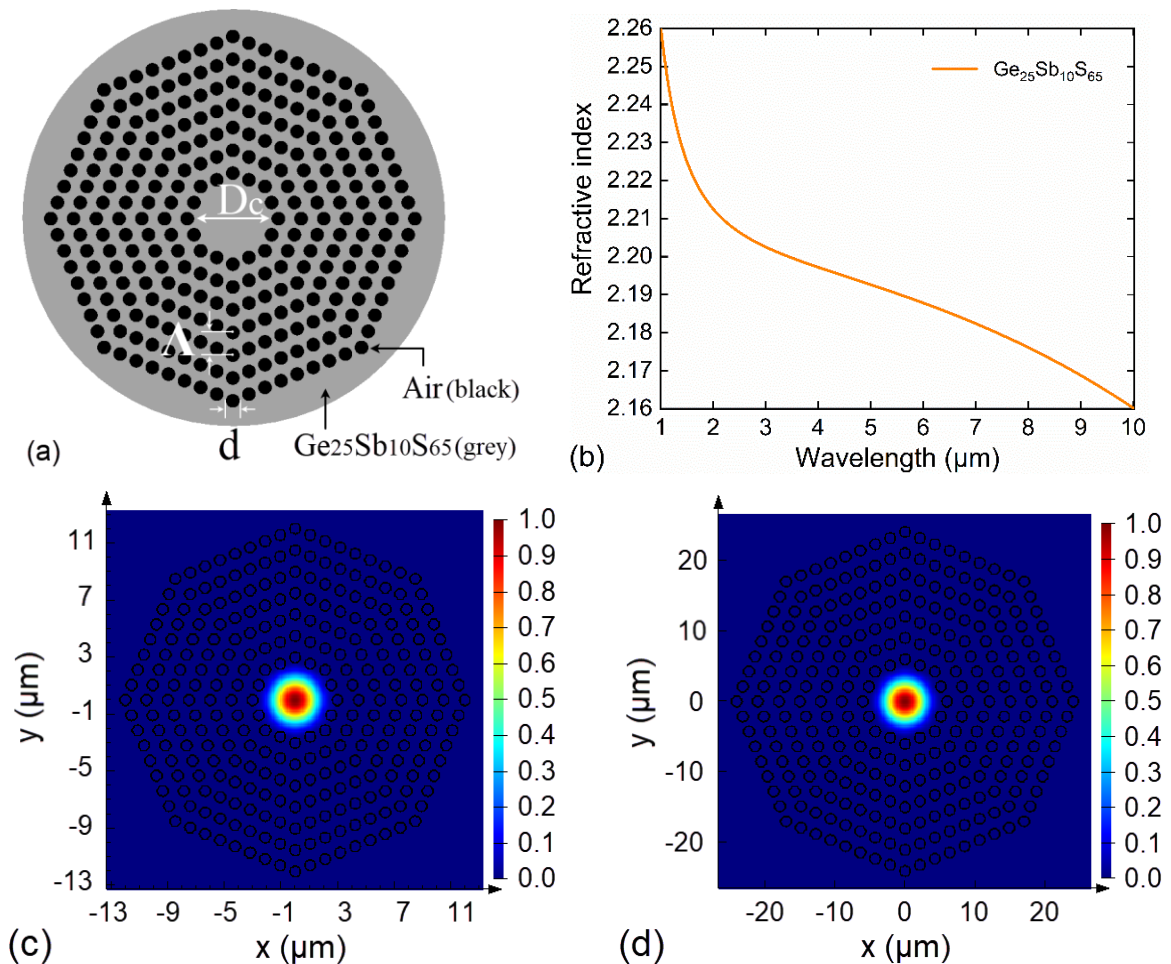


Figure 1. (a) Simulated cross sectional configuration of the proposed $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ -based LMA-PCFs with an octagonal cladding, where seven rings of air holes (black) surround the central region; (b) refractive index dispersion of $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ glass over the wavelength range of 1–10 μm obtained from the Sellmeier model; (c-d) simulated electromagnetic field profiles confined within the core region of LMA-PCFs at 3.6 μm for (c) $A = 1.5 \mu\text{m}$, $d = 0.45 \mu\text{m}$ ($d/A = 0.3$) and (d) $A = 2.5 \mu\text{m}$, $d = 0.75 \mu\text{m}$ ($d/A = 0.3$).

The geometrical designs and numerical analyses of the LMA-PCFs are carried out in the LMS (Lumerical Mode Solutions) platform with the FDE algorithm, which is based on a full vectorial finite-difference

scheme. The coefficients A_i and B_i in the refractive index expression $n(\lambda)$ for $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ host material (Eq.1) are obtained from the Sellmeier relation. Figure 1(a) displays the cross sectional structure of the proposed LMA-PCFs where the $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ host glass is represented by the gray region, while the air holes are shown in black. Seven rings of air holes with diameter d are regularly arranged in an octagonal cladding with pitch Λ . This design excludes the first layer closest to the core, which forms a large core with diameter $D_c = 4\Lambda - d$. The octagonal structure provides high geometric symmetry, enhancing the flexibility of controlling the optical properties of the LMA-PCFs. To study the light guiding characteristics under different structural configurations, the air filling fraction is varied within $d/\Lambda = 0.3 - 0.7$, while the lattice pitch Λ is set to 1.5, 2.0, 2.5, and 3.0 μm . The combined variation of d/Λ and Λ allows a systematic investigation of the influence of structural parameters on the electromagnetic field confinement in the fiber core, quantified by the effective refractive index $n_{\text{eff}}(\lambda)$, effective mode area $A_{\text{eff}}(\lambda)$, as well as the optical leakage properties evaluated through the confinement loss $CL(\lambda)$ of the $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ -based LMA-PCFs in the 1 – 10 μm region.

Figure 1(b) shows the $n(\lambda)$ curve of $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ glass according to the Sellmeier model, with the decrease of n as λ increases in the 1 - 10 μm range. This indicates the typical material dispersion behavior of $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ glass. The relatively high of $n(\lambda)$ (decreasing from approximately 2.2 to 2.18 in the 3 – 10 μm infrared region) enhances optical mode confinement and strengthens nonlinear optical effects, making it suitable for SCG applications in this wavelength range. The formula for $n(\lambda)$ in the Sellmeier model (Hu et al., 2021) is:

$$n(\lambda) = \sqrt{1 + \frac{A_1 \lambda^2}{\lambda^2 - B_1^2} + \frac{A_2 \lambda^2}{\lambda^2 - B_2^2}} \quad (\text{Eq.1}),$$

with $A_1 = 3.836$, $A_2 = 1.1528$, $B_1 = 0.25878$, $B_2 = 27.746$.

The theoretical model of $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ -based LMA-PCFs is formulated as an FDE problem derived from Maxwell's equations in the frequency domain (Dudley & Taylor, 2010):

$$\frac{\partial^2 E(r, \omega)}{\partial z^2} + k(\omega^2) E(r, \omega) = \Delta_{\perp} E(r, \omega) - \mu_0 \omega^2 P_{\text{NL}}(r, \omega) \quad (\text{Eq.2}),$$

where $E(r, t)$ and $E(r, \omega)$ correspond to the electric field in the time and frequency domains, respectively, $k(\omega) = n(\omega)\omega / c$ is the wave number, and $P_{\text{NL}}(r, \omega)$ represents the nonlinear polarization of the medium. In this work, only the linear eigenmode problem is considered; thus, the nonlinear polarization term is neglected ($P_{\text{NL}}(r, \omega) = 0$).

The perfectly matched layer (PML) boundary conditions and a uniform 300×300 Yee-based computational grid (Yu & Chang, 2004) are adopted for the numerical solution of Maxwell's equations. A minimum grid size of $10^{-6} \mu\text{m}$ is used to enhance the accuracy of the simulation, especially near the core-cladding interface. The role of PML is to suppress artificial reflections at the edges of the computational domain. Figures 1(c) and 1(d) manifest that the fundamental mode remains tightly localized in the core of the LMA-PCFs at 3.6 μm for $\Lambda = 1.5 \mu\text{m}$, $d = 0.45 \mu\text{m}$ ($d/\Lambda = 0.3$) and $\Lambda = 2.5 \mu\text{m}$, $d = 0.75 \mu\text{m}$ ($d/\Lambda = 0.3$), respectively.

The $n_{\text{eff}}(\lambda)$, $A_{\text{eff}}(\lambda)$ and $CL(\lambda)$ of the LMA-PCF designs are calculated using the following formulas:

$$n_{\text{eff}}(\lambda) = \frac{\beta(\lambda)}{k_0}, \quad k_0 = \frac{2\pi}{\lambda} \quad (\text{Eq.3}),$$

$$A_{\text{eff}}(\lambda) = \frac{\left(\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} |E|^2 dx dy \right)^2}{\int_{-\infty}^{\infty} \int_{-\infty}^{\infty} |E|^4 dx dy} \quad (\text{Eq.4}),$$

$$CL(\lambda) = 8.686 \frac{2\pi}{\lambda} \text{Im}[n_{\text{eff}}(\lambda)] \quad (\text{Eq.5}),$$

where $\beta(\lambda)$, k_0 , $E(x, y)$ and $\text{Im}[n_{\text{eff}}(\lambda)]$ are the propagation constant of the fundamental mode, the wave number in vacuum, the transverse electric field distribution, and the imaginary part of the $n_{\text{eff}}(\lambda)$, respectively.

3. MODAL ANALYSIS FOR SCG APPLICATIONS

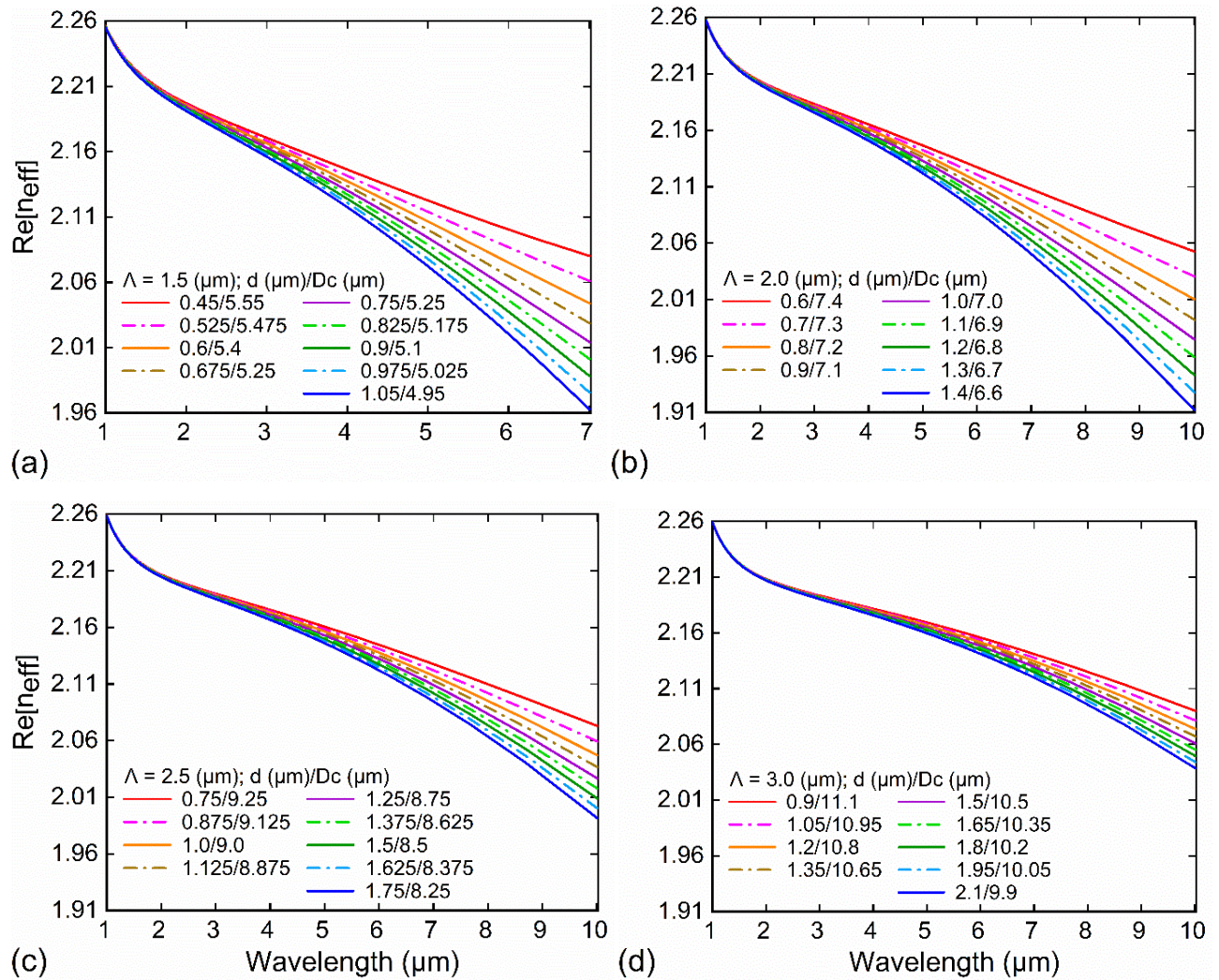


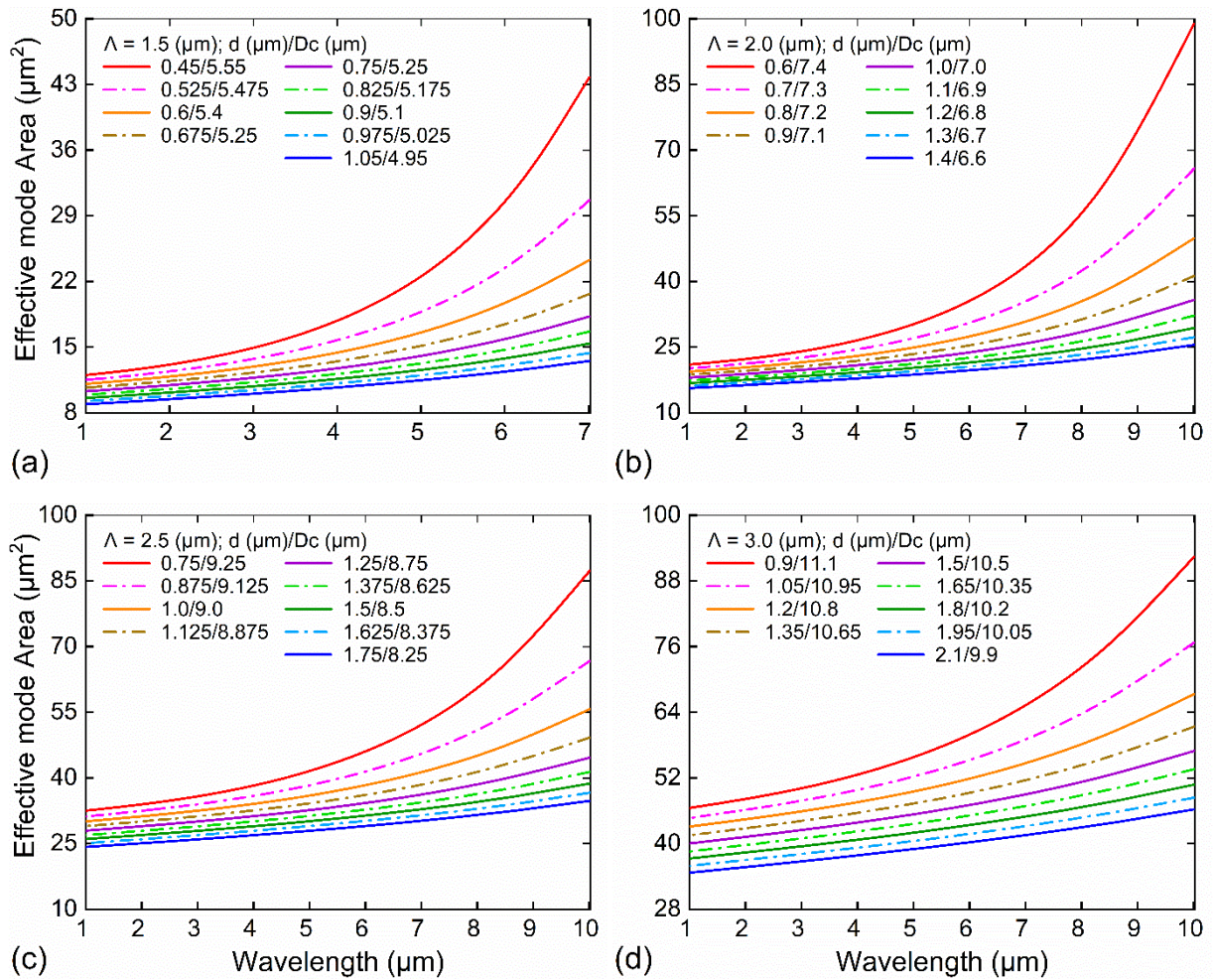
Figure 2. Real component of the effective refractive index $Re[n_{eff}]$ versus wavelength for the proposed $Ge_{25}Sb_{10}S_{65}$ -based LMA-PCFs. Figures (a-d) correspond to $\Lambda = 1.5, 2.0, 2.5$, and $3.0 \mu m$, respectively, illustrating the influence of Λ , d , and D_c on the modal guiding characteristics in the mid-IR region.

Across the entire surveyed wavelength range, $Re[n_{eff}]$ decreases monotonically with increasing wavelength (figure 2), indicating a gradual reduction in modal confinement as the field increasingly extends into the cladding at longer wavelengths. For a fixed Λ , increasing the air-hole diameter d or d/Λ consistently reduces $Re[n_{eff}]$ over the entire spectrum due to the higher air filling fraction in the cladding. At the same time, the increase in d reduces the suspended core diameter (D_c), further weakening field confinement in the core region. These effects collectively lead to a lower $Re[n_{eff}]$, particularly pronounced in the long-wavelength regime where modal expansion into the cladding is stronger. The core diameter D_c in the octagonal LMA-PCF governs the guiding properties, with $D_c = 4\Lambda - d$ directly linking it to the structural parameters. An increase in D_c enhances mode confinement in the core, leading to higher $Re[n_{eff}]$, over the investigated wavelength range. At a fixed d/Λ , increasing Λ therefore simultaneously enlarges both D_c and the effective mode area, improving guidance in LMA-PCF structures while reducing core power density and enhancing high-power handling capability (Abdelaziz et al., 2010).

The trend in figure 2 is further confirmed by the quantitative values of $Re[n_{eff}]$ at $\lambda = 3.6 \mu m$ listed in table 1, where $Re[n_{eff}]$ decreases with increasing d/Λ for a fixed Λ . For example, at $\Lambda = 1.5 \mu m$, $Re[n_{eff}]$ drops from 2.156 to 2.134 when d/Λ increases from 0.3 to 0.7. A similar behavior is observed for larger Λ values, indicating that increasing air-hole size together with the reduced core dimension D_c weakens mode confinement in the core region. In addition, for the same d/Λ ratio, structures with larger Λ consistently exhibit higher $Re[n_{eff}]$. This reflects the role of a larger-core configuration in improving waveguiding performance and maintaining more stable mode confinement in the mid-infrared region.

Table 1. Calculated values of $\text{Re}[n_{\text{eff}}]$ at $\lambda = 3.6 \mu\text{m}$ for the proposed $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ -based LMA-PCFs with different structural parameters (d/Λ and Λ)

d/Λ	$\Lambda = 1.5 \mu\text{m}$	$\Lambda = 2.0 \mu\text{m}$	$\Lambda = 2.5 \mu\text{m}$	$\Lambda = 3.0 \mu\text{m}$
0.3	2.156	2.172	2.181	2.186
0.35	2.152	2.171	2.18	2.186
0.4	2.149	2.169	2.179	2.185
0.45	2.146	2.168	2.179	2.185
0.5	2.144	2.167	2.178	2.184
0.55	2.141	2.165	2.177	2.183
0.6	2.139	2.164	2.176	2.183
0.65	2.136	2.162	2.175	2.182
0.7	2.134	2.161	2.174	2.182

**Figure 3.** The A_{eff} versus wavelength for the proposed $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ -based LMA-PCFs. Figures (a-d) correspond to $\Lambda = 1.5, 2.0, 2.5$, and $3.0 \mu\text{m}$, respectively, showing the influence of Λ , d , and D_c on effective mode expansion in the mid-IR region.

As shown in figure 3, the A_{eff} values of all investigated LMA-PCFs increase with wavelength. At longer wavelengths, the electromagnetic field expands further into the cladding, leading to an increase in A_{eff} . In addition, increasing the lattice constant Λ expands the entire fiber structure, resulting in a larger effective core region and weaker mode confinement, which further enhances A_{eff} . This behavior is consistent with the nature of LMA structures, which not only maintain a large A_{eff} to reduce optical power density and mitigate unwanted nonlinear effects, but also enhance high-power transmission capability in the mid-IR region (Ren et al., 2019; Yi et al., 2013). Conversely, at a fixed Λ , increasing the d/Λ ratio enlarges the air hole size and reduces the core diameter D_c , leading to tighter optical confinement within the core and a smaller A_{eff} . Table 2 quantitatively confirms the observed trends at $\lambda = 3.6 \mu\text{m}$. Specifically, A_{eff} increases from $16.497 \mu\text{m}^2$ to $51.528 \mu\text{m}^2$ when Λ increases from 1.5 to 3.0 μm at $d/\Lambda = 0.3$. Conversely, for $\Lambda = 3.0 \mu\text{m}$, A_{eff} decreases from $51.528 \mu\text{m}^2$ to $38.787 \mu\text{m}^2$ as d/Λ increases from 0.3 to 0.65. The relatively large A_{eff} values indicate

that the proposed octagonal PCF structure is a promising candidate for mid-IR LMA-PCF applications.

Table 2. Calculated values of A_{eff} at $\lambda = 3.6 \mu\text{m}$ for the proposed $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ -based LMA-PCFs with different structural parameters (d/Λ and Λ)

d/Λ	$\Lambda = 1.5 \mu\text{m}$	$\Lambda = 2.0 \mu\text{m}$	$\Lambda = 2.5 \mu\text{m}$	$\Lambda = 3.0 \mu\text{m}$
0.3	16.497	25.45	37.183	51.528
0.35	14.847	23.672	35.077	48.984
0.4	13.756	22.365	33.414	46.865
0.45	12.964	21.336	32.028	45.007
0.5	12.307	20.422	30.753	43.275
0.55	11.771	19.631	29.612	41.703
0.6	11.282	18.888	28.539	40.217
0.65	10.843	18.198	27.522	38.787
0.7	10.426	17.535	26.531	37.405

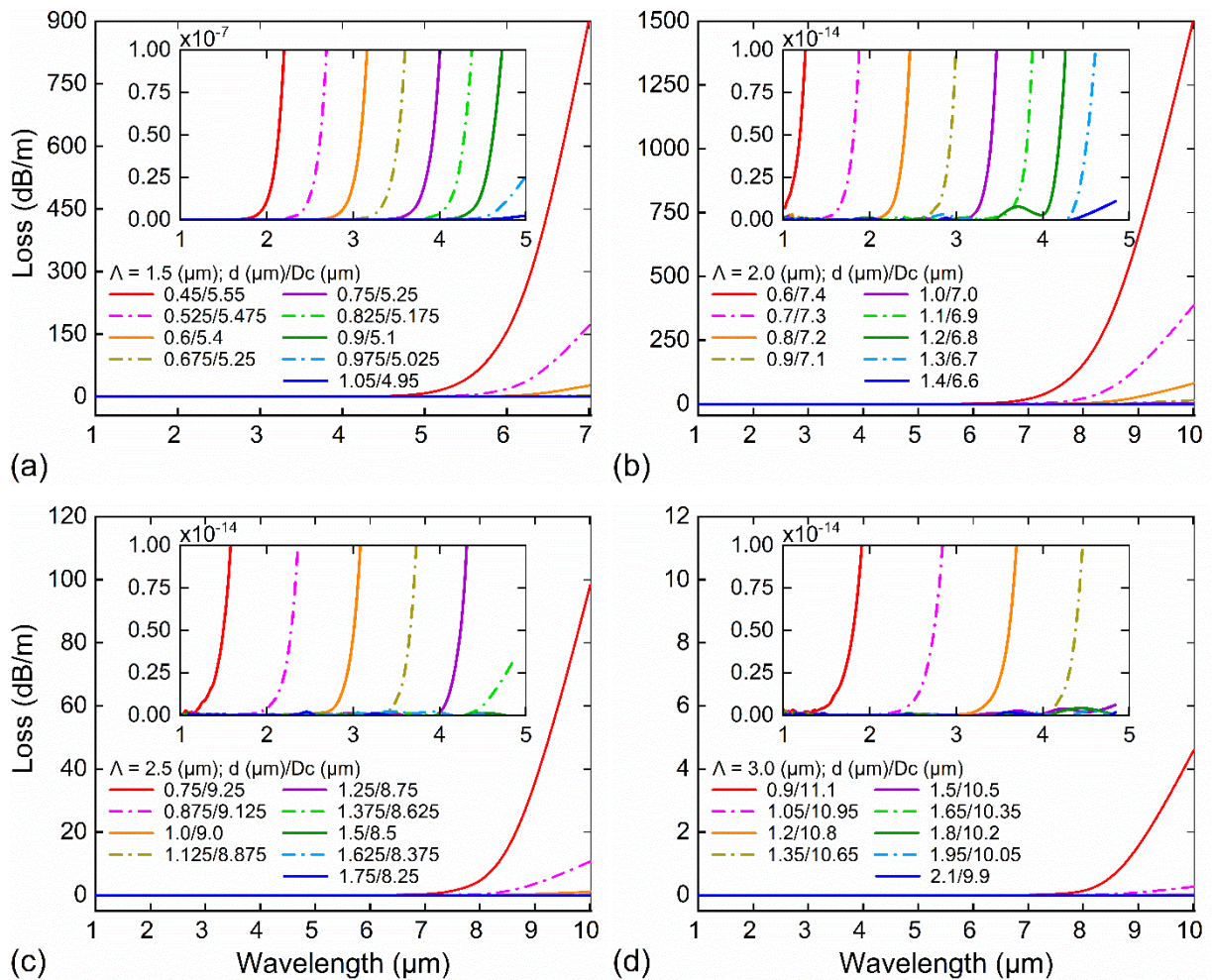


Figure 4. The CL versus wavelength for the proposed $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ -based LMA-PCFs.

Figures (a-d) correspond to $\Lambda = 1.5, 2.0, 2.5$, and $3.0 \mu\text{m}$, respectively, highlight how Λ , d , and D_c affect on leakage loss characteristics in the mid-IR region.

The CL values are strongly influenced by the structural parameters d , D_c and Λ , as exposed in figure 4. Insets show enlarged views of the ultra-low-loss region, with the y-axis expressed in scientific notation ($\times 10^{-14}$ or $\times 10^{-7}$), the unit remains dB/m. For $\Lambda = 1.5 \mu\text{m}$ (figure 4a), structures with low d/Λ exhibit a sharp increase in loss beyond approximately $4 - 5 \mu\text{m}$. At $d/\Lambda = 0.3$, CL reaches nearly 900 dB/m at $7 \mu\text{m}$, implying weaker field localization within the core region. When d/Λ increases to $0.6 - 0.7$, the CL drops sharply and becomes nearly negligible (approaching 0 dB/m) over most of the investigated spectral range. This confirms that larger air holes significantly enhance the confinement capability of the structure. For $\Lambda = 2.0 \mu\text{m}$ (figure 4b), a similar trend is observed, but with an overall lower loss level at the corresponding wavelengths. In particular, LMA-PCF with $d/\Lambda > 0.4$ has almost negligible CL in the $1 - 10 \mu\text{m}$ region. This

indicates that increasing A helps stabilize the modal distribution in the core while reducing electromagnetic field leakage into the cladding. The calculated CL at $\lambda = 3.6 \mu\text{m}$ (table 3) also evince a consistent trend, where CL decreases significantly from 1.103×10^{-5} to 5.937×10^{-16} dB/m as the d/A ratio rises from 0.3 to 0.6. In particular, for $d/A \geq 0.45$, the CL is reduced to the order of $10^{-12} - 10^{-16}$ dB/m, indicating a substantial improvement in mode confinement, with leakage loss becoming practically negligible in terms of its impact on fiber transmission characteristics. When A is increased to 2.5 and 3.0 μm (figure 4c and d), the CL drops to an extremely low level, typically on the order of 10^{-14} dB/m over the 1 – 7 μm range for $d/A < 0.4$. In these cases, even at wavelengths beyond 8 μm , LMA-PCFs with $d/A \geq 0.4$ maintain stable guiding characteristics with ultra-low CL , indicating highly efficient confinement in the mid-IR regime. However, it should be noted that in Ge-Sb-S glasses, the total loss is not determined solely by confinement loss, but is also significantly influenced by intrinsic material absorption. Experimental studies on Ge-Sb-S glasses show that the low-loss transmission window typically lies in the 2 – 8 μm range, while multiphonon absorption increases rapidly beyond $\sim 9 - 10 \mu\text{m}$ (Lee et al., 2018). Although the simulations indicate that confinement loss remains extremely low at longer wavelengths, the actual transmission bandwidth of the fiber is ultimately limited by intrinsic material absorption. This is particularly important when assessing its potential for mid-IR SCG. For LMA-PCF with high d/A , CL is no longer the dominant limiting factor; instead, the intrinsic loss of Ge-Sb-S glass governs the long-wavelength limit. Therefore, the effective operating window of the proposed designs is most likely within 2 – 7 μm , where both confinement and material losses remain sufficiently low to support high spectral power and stable nonlinear dynamics (Feng et al., 2021).

Compared with previous chalcogenide fiber designs featuring extremely large mode areas, such as 1962 μm^2 in a $\text{Ge}_{20}\text{Sb}_{15}\text{S}_{65}$ multi-core PCF (Yi et al., 2013), around 5200 μm^2 in an all-solid chalcogenide PCF (Ren et al., 2019), and nearly 9900 μm^2 in an $\text{As}_2\text{Se}_3/\text{As}_2\text{S}_3$ PCF for high-power mid-IR laser delivery (Wang et al., 2025), the proposed octagonal $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ -based LMA-PCFs maintain a relatively large effective mode area. This is sufficient to reduce optical power density and improve mode stability. While ultra-large mode area PCFs are mainly suitable for high-power delivery and mitigation of nonlinear damage, they typically suffer from a reduced nonlinear coefficient, which limits their efficiency for SCG. In contrast, the proposed design achieves a better balance between a large mode area, ultra-low confinement loss, and strong nonlinear interaction enabled by the high nonlinearity of $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$. This makes the structure more suitable for mid-IR SCG applications requiring broad, stable spectra and efficient nonlinear conversion (Genty et al., 2005; Shen et al., 2018; Jiang et al., 2015; Ademgil & Haxha, 2012; Van et al., 2025).

Table 3. Calculated values of CL at $\lambda = 3.6 \mu\text{m}$ for the proposed $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ -based LMA-PCFs with different structural parameters (d/A and A)

d/A	$A = 1.5 \mu\text{m}$	$A = 2.0 \mu\text{m}$	$A = 2.5 \mu\text{m}$	$A = 3.0 \mu\text{m}$
0.3	9.168×10^{-3}	1.103×10^{-5}	5.176×10^{-8}	7.511×10^{-10}
0.35	1.862×10^{-4}	9.796×10^{-8}	2.374×10^{-10}	2.167×10^{-12}
0.4	3.814×10^{-6}	7.929×10^{-10}	8.782×10^{-13}	4.187×10^{-15}
0.45	7.947×10^{-7}	5.679×10^{-12}	2.256×10^{-15}	1.922×10^{-16}
0.5	1.732×10^{-9}	3.785×10^{-14}	9.916×10^{-18}	1.676×10^{-16}
0.55	4.108×10^{-11}	3.586×10^{-16}	1.494×10^{-16}	3.122×10^{-17}
0.6	1.058×10^{-12}	5.937×10^{-16}	1.002×10^{-16}	1.826×10^{-16}
0.65	3.142×10^{-14}	2.395×10^{-16}	1.592×10^{-16}	1.065×10^{-16}
0.7	2.074×10^{-15}	3.550×10^{-14}	2.934×10^{-16}	2.934×10^{-16}

4. CONCLUSION

A total of 36 octagonal $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ -based LMA-PCF structures are designed and systematically investigated using the FDE method to evaluate the influence of the structural parameters A , d , and D_c on the fundamental-mode waveguiding characteristics in the mid-IR region. The results show that the proposed structures large mode area characteristics, on the order of a few tens of μm^2 , together with ultra-low confinement loss. In particular, the average CL is on the order of 10^{-8} dB/m in the 1 – 5 μm range, indicating efficient mode confinement and suitable conditions for selecting pump wavelengths within the key operating window of mid-IR SCG systems. Increasing A leads to mode expansion, while increasing d/A significantly enhances confinement and suppresses leakage into the cladding. In addition, the octagonal lattice improves modal stability and guiding performance at longer wavelengths. Compared with ultra-large-mode-area designs featuring A_{eff} on the order of thousands of μm^2 , the proposed structures preserve stronger nonlinear interaction due to the high nonlinear of $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$. This balance between mode area, confinement loss, and nonlinearity makes the proposed design a promising candidate for broadband, low-loss mid-IR SCG

applications.

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Đặc tính dẫn sóng của sợi quang $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ mạng bát giác có diện tích mode lớn

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TÓM TẮT

Các sợi quang lõi rắn với cấu trúc lõi lớn ($D_c = 4\Lambda - d$) thường cung cấp diện tích mode hiệu dụng lớn, mang lại tiềm năng cho nhiều ứng dụng quang tử. Trong công trình này, một sợi quang tinh thể quang tử hình bát giác dựa trên thủy tinh $\text{Ge}_{25}\text{Sb}_{10}\text{S}_{65}$ được đề xuất và phân tích bằng phương pháp số. Vùng lõi lớn được hình thành bằng cách loại bỏ vòng lỗ khí thứ nhất bao quanh tâm sợi. Kết quả cho thấy cấu trúc được đề xuất duy trì diện tích mode hiệu dụng tương đối lớn, khoảng $10 - 100 \mu\text{m}^2$ trong dải bước sóng từ 1 đến $10 \mu\text{m}$. Ngoài ra, trong vùng $1 - 7 \mu\text{m}$, sợi đạt được tổn hao giam giữ cực thấp với giá trị trung bình cỡ 10^{-8} dB/m. Những đặc tính này cho thấy tiềm năng ứng dụng của sợi tinh thể quang tử được đề xuất trong truyền tải công suất cao, quang học phi tuyến và hệ thống quang tử hồng ngoại tầm trung.