

MID-INFRARED SUPERCONTINUUM GENERATION IN A FOUR-HOLE AsSe₂ CHALCOGENIDE SUSPENDED-CORE FIBER

Do Thanh Thuy¹, Nguyen Tien Dung², Dinh Xuan Khoa¹, Bui Dinh Thuan¹, Luu Tien Hung¹, Doan The Ngo Vinh¹, Do Hong Son¹, Phan Quang Triet³, Le Canh Trung^{1*}

¹) Lab for Photonic Crystal Fiber, Vinh University, 182 Le Duan Street, Vinh City, Nghe An province, Viet Nam

²) School of Engineering and Technology, Vinh University, 182 Le Duan Street, Vinh City, Nghe An province, Viet nam

³) Phan Boi Chau High School, Vinh University, 182 Le Duan Street, Vinh City, Nghe An province, Viet Nam

*E-mail: trunglc@vinhuni.edu.vn

Abstract:

In this work, we designed a suspended core optical fiber with 4 air holes impregnated with CS₂ and using AsSe₂ substrate. We investigated the characteristics of this optical fiber and its application in supercontinuum emission in the mid-infrared region. As a result, with low laser power, we obtained a supercontinuum emission spectrum from 1900 nm to 5100 nm wavelength.

1. Introduction

Supercontinuum (SC) generation in the silica microstructured optical fibers (MOFs) has attracted the interest of researchers due to its excellent properties and extensive applications in nonlinear optics [1–6]. However, silica MOFs have two main limitations: low nonlinearity and narrow transmission range in the mid-infrared (MIR) region. The recent trend in SC research is to extend its spectral range up to MIR for pushing further the application in military, medical, biologic and sensing systems [7–10]. To satisfy this demand, soft-glass fibers, including fluoride, tellurite and chalcogenide fibers, are promising candidates for SC generation [11–13].

Among the soft glasses, chalcogenide fibers are promising waveguides for broadband SC generation since they possess higher nonlinearity and wider transmission range. Depending on the compositions, the nonlinear refractive indices of chalcogenide glasses are tens or hundreds times those of fluoride and tellurite glasses, and the transmission range is from visible up to MIR region.

In this paper, we design a suspended core photonic crystal fiber with 4 air holes impregnated with CS₂ using AsSe₂ glass that can realize broadband SC in MIR regime.

2. Study on dispersion properties of CS₂ impregnated 4-air-hole suspended core photonic fiber with AsSe₂ substrate

We used Lumerical Mode Solutions software to design a suspended core photonic crystal fiber consisting of four CS₂ air-permeable holes using AsSe₂ substrate as shown in Figure 1.

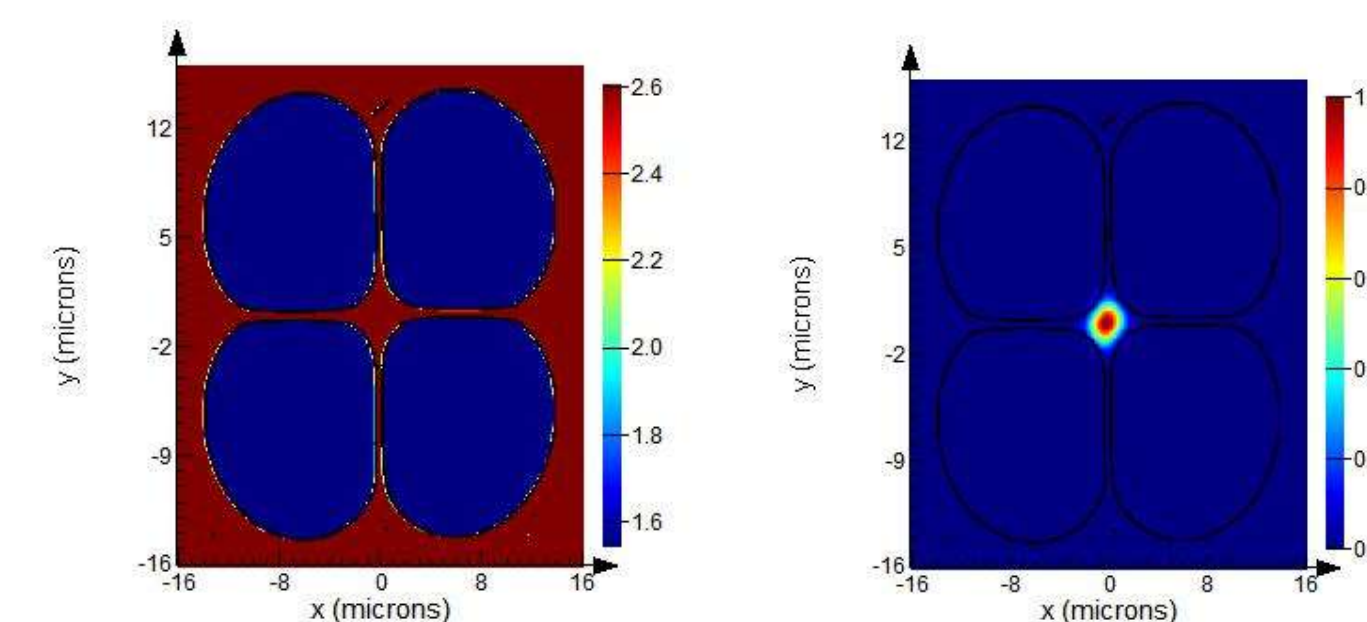


Figure 1.

We use Lumerical Mode Solutions software and change the core diameter from 1.1 μm to 4.9 μm. As a result, we obtain the dispersion characteristics of the suspended core optical fiber as shown in Figure 2. When we varied the core diameter we found that as the core diameter increased the dispersion point moved further away from the red light region. When the core diameter Dc=4.9μm, the dispersion characteristic curve is almost flat from 3.2 μm to 5 μm. With this result, we choose CS₂ permeable suspended core optical fiber with diameter 4.9 μm for our supercontinuum generation research.

We investigate the dependence of mode area and nonlinear coefficient on wavelength and the results are shown in Figure 3.

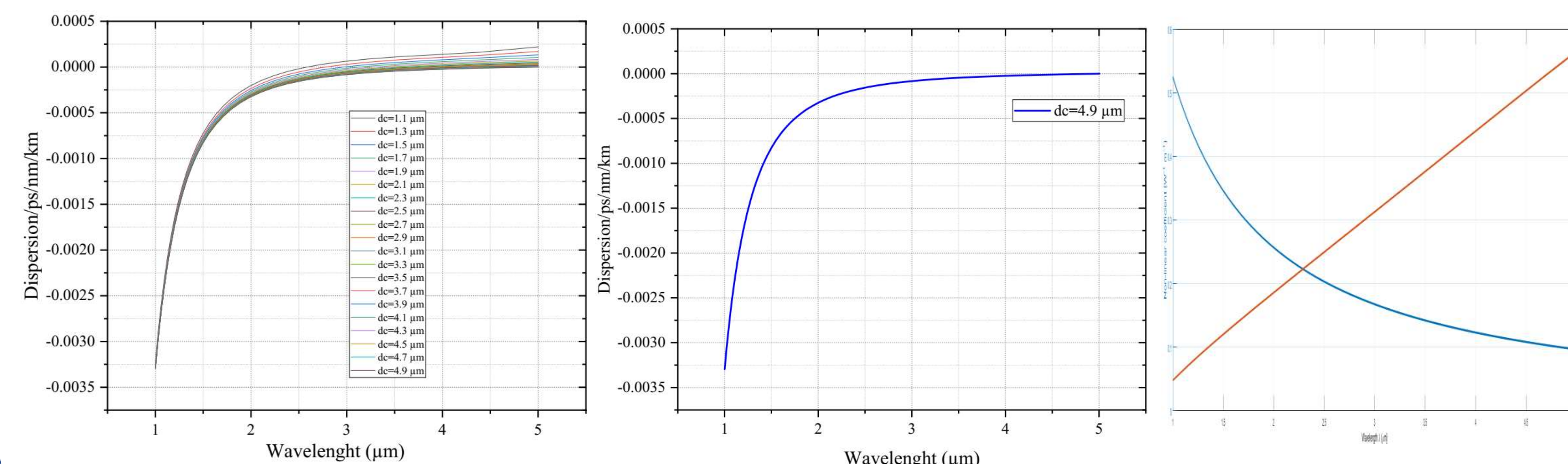


Figure 2.

Figure .3

3. Study of supercontinuum generation in suspended core optical fiber

To investigate the supercontinuum generation process we use the GNLS equation:

$$\frac{\partial}{\partial z} A(z, t) = -\frac{\alpha}{2} A(z, t) + \sum_{m \geq 2} \beta_m \frac{i^{m+1}}{m!} \frac{\partial^m}{\partial t^m} A(z, t) + i\gamma \left(1 + \frac{i}{\omega_0} \frac{\partial}{\partial t} \right) \left[A(z, t) \int_{-\infty}^{+\infty} R(t') |A(z, t - t')|^2 dt' \right] \quad (1)$$

Finally the material response function includes both the instantaneous electronic response (Kerr type) and the delayed Raman response and has the form

$$R(t) = (1 - f_R) \delta(t) + f_R h_R(t) \quad h_R(t) = \frac{\tau_1^2 + \tau_2^2}{\tau_1 \tau_2} \exp\left(-\frac{t}{\tau_2}\right) \sin\left(\frac{t}{\tau_1}\right)$$

We use a pump laser with a pump wavelength of 3000nm and a pulse width of 100fs. We change the peak power of the pump laser beam to 30kW; 15kW and 5k W, the spectra we obtain are shown in Figure 4. We see that when the pump beam power is increased, the spectral width is broadened.

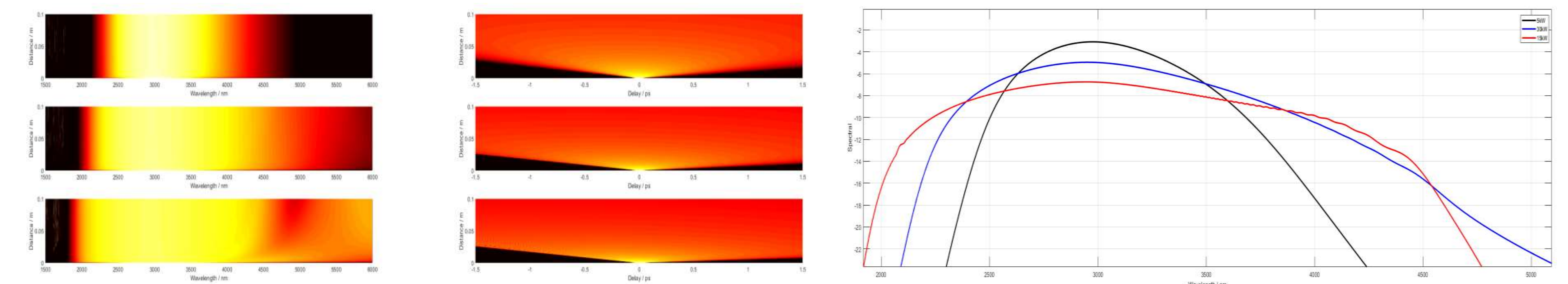


Figure 3.

In figure 5 we study the spectrum broadening when changing the width of the pump laser pulse and the result we get is that when increasing the pulse width, the output spectrum broadening narrows.

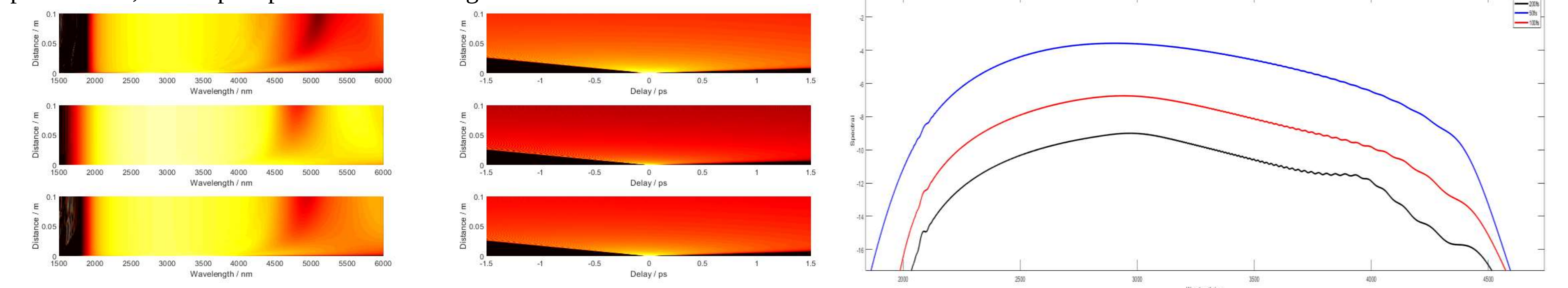


Figure 4.

4. Conclusions

In this paper we have designed a suspended core optical fiber with 4 air holes impregnated with CS₂ using AsSe₂ substrate. As a result we have obtained a fiber with a core diameter of Dc=4.9μm for a flat dispersion characteristic from 3.2 μm to 5 μm wavelength and located in the normal dispersion region. We used this structure to study supercontinuum generation and as a result we have obtained an output spectrum extending from 1900 nm to 5100 nm for a pump laser with a pump wavelength of 3000nm, a pump power of 30kW and a pump pulse width of 100fs.

Acknowledgments

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