NANYANG TECHNOLOGICAL UNIVERSITY

SIMTech

URECA
Undergraduate Research Experience on CAmpus

Category: 3
School of Electrical and Electronic Engineering
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Project ID: EEE11127

Imaging Fiber Design for Medical Applications

Objective

To design a broad-band imaging fiber for lossless delivery of CO_2 laser for medical applications.

Introduction

A medical laser delivery system transmits laser energy to a surgical site of a patient, however 30% of the energy will be lost during the transmission. Our new design provides a solution to the problem. Firstly, it maximizes the bandwidth by using high-refractive-index matrix to compensate the material dispersion permitting high input energy by broad-band wave transmission. Secondly, it decreases the loss by using periodic microstructures within photonic crystal fibers (PCFs) as well as alternating layers (n_1/n_2) of dielectrics deposited on a metal film inside the hollow core.

Principles

•Effective refractive index:

$$n_{eff} = \mathrm{Re}(n_{eff}) + j\mathrm{Im}(n_{eff})$$

•Mode guiding loss:

$$L(\mathrm{dB/m}) = \frac{40\pi Im(n_{eff})}{\lambda \ ln10}$$

•Dispersion parameter:

$$D = -\frac{\lambda}{c} \times \frac{\partial^2 R(n_{eff})}{\partial \lambda^2} \quad (\lambda \text{ in } \mu m)$$

Conclusion

- Various types of infrared fibers and light guiding principles have been studied.
- Schematic structure of the fiber has been designed, and a 3-layer PCF has been constructed and simulated using RSoft.
- The relationship between waveguide dispersion D_w and λ has been investigated.
- Future research will focus on the plasmonics enhancement of the fiber.

Structure

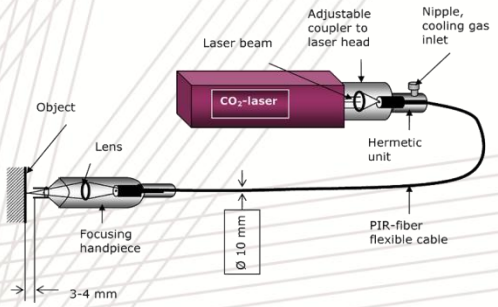

Figure 1. Fiber delivery set-up for CO_2 laser

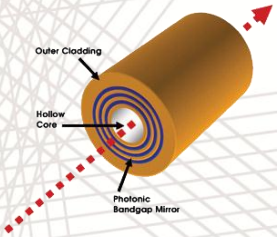

Figure 2. Photonic bandgap reflector

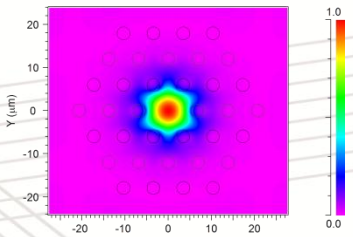

Figure 3. Ex mode profile of 3-layer PCF

Results

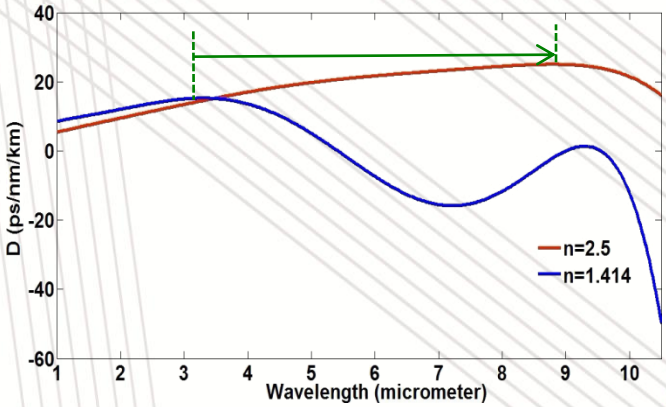

Figure 4. Waveguide dispersion D_w vs. λ for PCF with different n_{matrix}, for compensating highly negative material dispersion D_m and maximizing the bandwidth

Project Title: Plasmonics enhanced imaging fiber of medical diagnosis
Supervisor: Prof Shum Ping
Co-supervisor: Dr Yu Xia Mandy