Fibre Optics:
A Renaissance in Bio-medical Engineering Field

Harvinder Singh Josan
M.Tech in Electronics &Communication
LPU-Lovely Professional University
Phagwara, Punjab, India

Jaspal Singh
M.Tech in Electronics &Communication
LPU-Lovely Professional University
Phagwara, Punjab, India

***Abstract*—The fundament of the defined research is lay emphasis on Minimal Invasive Surgery (MIS) for performing medical operations today due it's lower cost, fastest healing, and minimal post-operative pain and discomfort to the treated patients. It is rapidly expanding with the development and miniaturization of two dimensional (2-D) and three-dimensional (3-D) endoscopic imaging systems. A number of research groups have suggested flexible waveguides for the mid- IR region between 2.5 and 11 um, which contains very important and useful laser wavelengths and it is not covered by the silica fibers. The gold goals for the development of such delivery devices are being analyzed.**

Keywords- CO laser, WG, MIS, Bio-medical, IR laser, RF

I. Introduction

Laser radiation has an important role in surgical procedures in various medical specialties. The CO laser (wavelength 10.6 m) is found to be a preferable substitute to the scalpel—the surgical knife. It cuts soft tissue much more precisely with almost no bleeding due to the hemostatic characteristics of this laser wavelength, and it is much more controllable than the knife. For hard tissue, the Er-YAG laser at the wavelength of 2.94 m is found to be a good tool for cutting and drilling. Besides these two lasers, there is a host of other wavelengths, each of them having a specific interaction with tissue, thus suitable to other applications [3]. Medical surgical procedures are developing and moving rapidly to a new concept of minimal invasive surgery (MIS). Instead of long operations requiring extensive cutting and opening of the body in order to reach the organ to be operated on, followed by a long healing period and post-operative pain and discomfort, the trend is now to perform operation through endoscopes, which are inserted through the existing opening of the body to the affected organ, or through minor cuts in the skin (in several procedures). The operation can be performed with miniature operation tools or electrical wires that are inserted through the working channels of the endoscopes. The visualization of the procedures is done through the optical bundle and on the monitors in the operating room (OR). This big step ahead could not have happened, of course, without the big progress of the endoscopy systems with two-dimensional (2-D) visualization and, now, stepping into three-dimensional (3-D) imaging [1, 3]. These MIS procedures are less expensive and less time consuming than open body operations. The postoperative pain is minimal if at all. The healing process is much shorter and hospitalizations periods are very short or do not exist at all, in most cases.

All standard paper components have been specified for three reasons: (1) ease of use when formatting individual papers, (2) automatic compliance to electronic requirements that facilitate the concurrent or later production of electronic products, and (3) conformity of style throughout conference proceedings. Margins, column widths, line spacing, and type styles are built-in; examples of the type styles are provided throughout this document and are identified in italic type, within parentheses, following the example. Some components, such as multi-leveled equations, graphics, and tables are not prescribed, although the various table text styles are provided. The formatter will need to create these components, incorporating the applicable criteria that follow.

II. MATERIALS AND METHODS

To describe thoroughly a waveguide, the following issues need to be addressed.

1. Energy Losses

The WG, need to have minimal losses that are as close as possible to be able to transmit most of the energy launched into it. The losses should also be minimal even when bent. Any energy loss may turn into heat and may cause damage to the WG, the endoscope,
or even damage the tissue.

2. Flexibility

Since a passage in the body through which the endoscope is inserted and maneuvered to reach the affected organ can cause multiple bending at very small radii of curvature. The WG should be capable of this bending without being damaged.

3. Output Beam Characteristics

The beam should be as close as possible to a smooth Gaussian beam which is usually launched into the WG (especially with the CO_2 laser). With the Gaussian beam, most of the energy is concentrated in the center so that high-energy concentration is achieved [3]. Any beam shape with hot spots in it may cause nonefficient interaction with tissue and an increase in thermal damage.

4. High Energy

The waveguide should be able to withstand high laser peak power in the pulsed mode or high overall energy in the CW mode. Higher energy enables more applications and less tissue damage the WG.

5. Toxicity and Bio-Compatabilty

The WG is inserted inside the body; thus it has to be nontoxic otherwise it will not be approved to be used medically by any of the regulatory agencies of any country.

6. Reliability

It is important to have a WG that will not break during use; also, the laser beam should not perforate through its walls under any circumstances.

7. Fabrication

Production procedures should allow a repeatable performance within a small tolerance so that reliable repeatable performance under various conditions
can expect.

8. Tunability

Since there are more than one wavelength to be covered, especially with the introduction of the free electron laser, it is preferable that by changing several production procedures the WG can be optimized to a specific range of wavelengths or be able to transmit a broad range of wavelengths.

9. Cost

Fabrication of the WG should be low cost so that the MIS can be competitive in price compared to the regular surgical procedures.

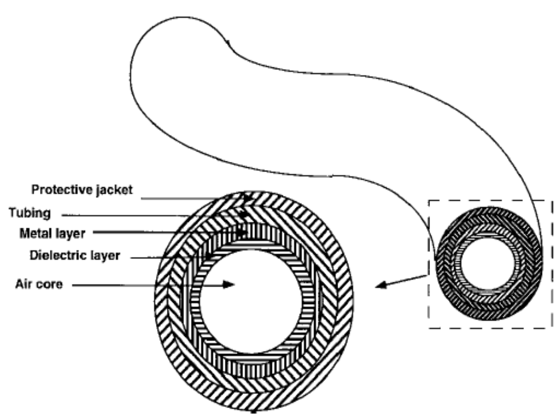


Figure.1.A Schematic drawing of a waveguide showing it's Components

A general scheme of a WG is illustrated in Fig. 1. The WG is made of a tube of various types of material, a metal layer, and a dielectric layer upon it. An external jacket is optional to either protect the surroundings from perforation or improve the flexibility of the carrier tubing. The laser beam is propagating through the air core of the WG by reflecting and refracting from the metal layer and in the dielectric layer, respectively. The flexibility of the WG is a function of the tubing used.

III. STABILITY OF MODE LOCKED LASERS

Metrology of optical frequencies in these days often deals with frequency synthesis through pulsed femtosecond mode locked lasers .Value of repetition rate of generated pulses determines (in the frequency domain) spacing of discrete coherent components of the whole super continuum. The spectrum of the super continuum has profile of a comb [5]. The device that generates the stable comb spectrum is called an optical synthesizer. It can convert stability of radio frequency (RF) repetition frequency into light spectral domain and vice versa. Therefore the synthesizer is considered as a very modern metrology tool because it bridges large gap between optical and radio frequency bands.

IV. MODULATED IR LASER RE-TRANSMITTER

The proposed methodology is applicable to Optical Laser Communication, and thus will give a boost to the industry of Laser Communication in a variety of different fields. In the purposed model for doing this project we have to synchronize the following things together:

- Modulated IR Laser Transmitter
- Modulated IR Receiver
- Modulated IR Sensor with regenerator for same

Laser using fiber optic laser communication. The underlying phenomenon of modulated I demodulated IR light detecting works by producing light from the emitter, which in the presence of an object is reflected by that object into a detector, thereby enabling the detection of the object.

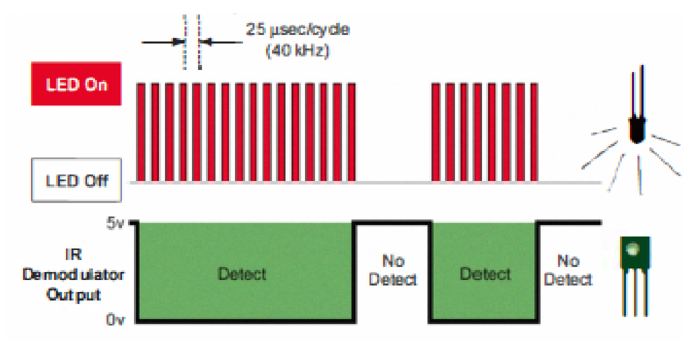


Fig.2.Modulated Laser Operation

The most common use for modulated IR is of communication. When the light source flashes at a particular frequency, the process is known as modulation. Signal is then sensed by a demodulator which has been adjusted to that frequency[6]. This whole process is a great way to offer resistance insensitivity to ambient light. The special characteristic of this process is that light flashes can be identified even if they are weak.

V. RESULTS AND DISCUSSION

1. Laakman–Levy Group

This WG is fabricated as follows: a silver flat ribbon is coated with a lead fluoride dielectric layer. This ribbon is then formatted into a tubular shape over which a metal cylindrical jacket is drawn down. A typical length of this WG is 1.1 m, the outer diameter (O.D.) is 1.2 mm, and the inner diameter (I.D.) 1.0 mm. Transmission at 10.6 m—when straight is 86% and curved to 25-cm radius, it reduces to 79%. No other information on other wavelengths is available since the company is only manufacturing CO lasers.

2. Morrow–Gu Group

This WG is a polished silver tube coated internally with silver halide layer. Polysulfone and TINELTM jackets protect the WG against kinks and local bends and enhancing the flexibility of the WG. Bending performance of this WG is shown in Fig. 2 since it is metal tube flexibility, is not so high, and the maximum bend radius is about 30 cm. The transmission at 10.6 m of 1-m long and 1.0-mm I.D. WG varies from 98% when straight down to 85% at the smaller bending radius possible.

3. Miyagi et al

This very productive group has introduced over the years a host of different waveguides and various fabrication and depositing techniques. Making use of a wide variety of metal and dielectric layers [3]. Among them, nickel and germanium, aluminum nickel and silicon, nickel silver, and zinc-sulfide. The WG is fabricated as follows: a polyimide (or polyimide with Aluminum) tube is used as a mandrel. The WG is formed on the mandrel by sputtering process and then the mandrel is removed by dissolving it at the end of the process. The mandrel maintains a perfect circular shape and leaves a very smooth WG, after being dissolved. To achieve low loss at a desired wavelength the thickness of the dielectric layers is determined according to the following equation:

$$d = \frac{\lambda}{2\pi(n^2-1)^{1/2}} \tan^{-1}\left[\frac{n}{(n^2-1)^{1/4}}\right]$$

In their long search for the most suitable materials for WG'sfabrication, Miyagi *et al.* have used polyimide fluorocarbon as the dielectric layer coated on an Ag metal tube. PI is nontoxic, heat resistant, and durable against acid and organic solutions or vapors.

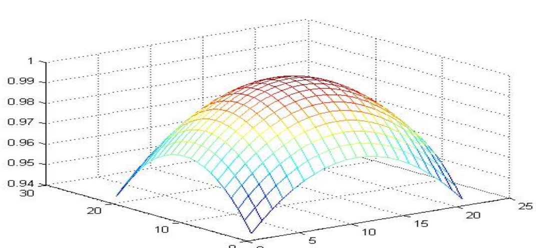


Fig.3. Measured beam profile of a bore of a straight WG at a defined distance from the output end.

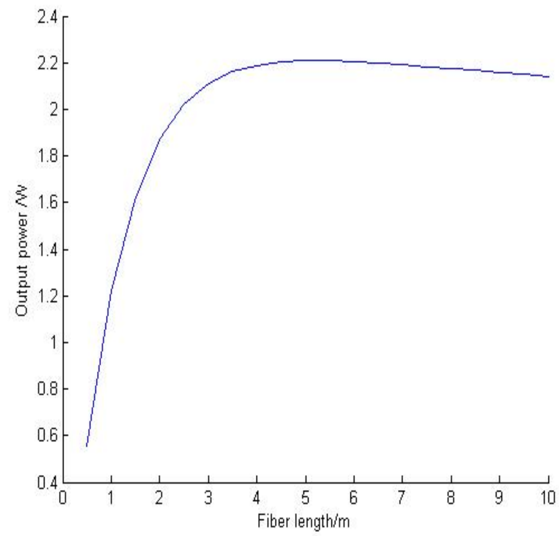


Fig.4.Transmiision of a fiberlase waveguide w.r.t. output power versus length of the fiber

Bending performance of a WG is shown in Fig. 4 since it is metal tube flexibility, is not so high, and the maximum bend radius is about 30 cm [3]. The transmission at 10.6 um of 1-m long and 1.0-mm I.D. WG varies from 98% when straight down to 85% at the smaller bending radius possible.

4. Harrington et al

This group has been known for their work for years on sapphire fibers and rigid hollow WG's. They have reported (in 1993) fabrication of small bore WG's which are fused silica tubing internally coated with silver and silver–iodide by electroless chemical methods. The spectral losses of this WG optimized for CO and Er-YAG lasers are shown in Figs.5 and 6, respectively.

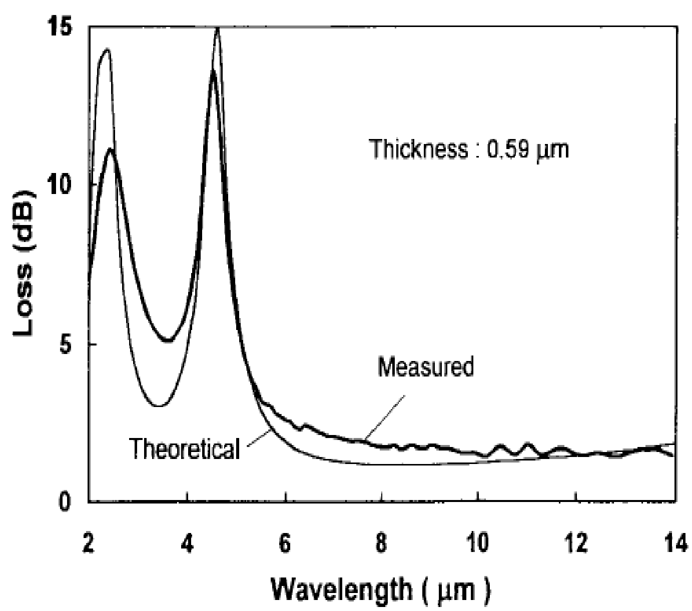
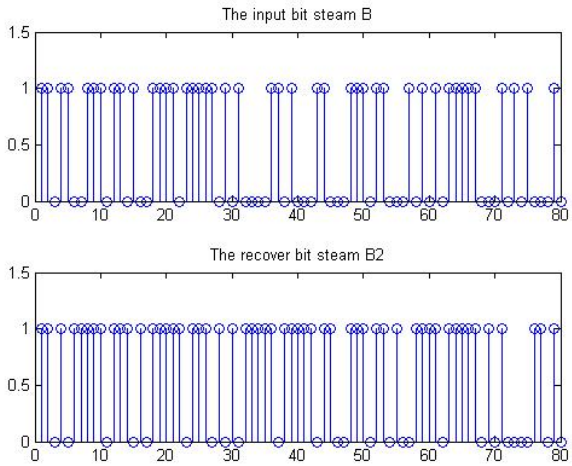
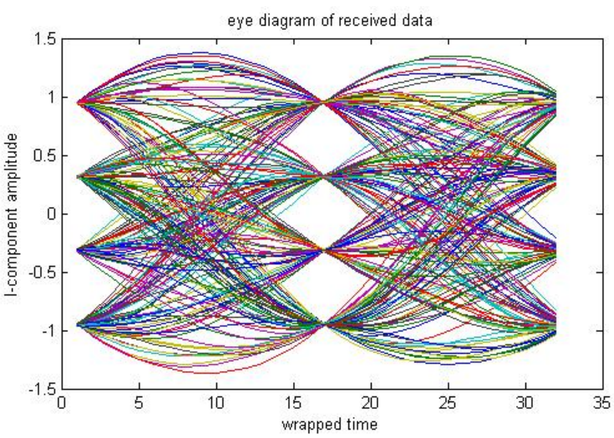


Fig.5. Spectral loss of the hollow glass WG designed for CO2 laser radiation transmission (ID = 530 _m, L = 20 cm).



(a)



(b)

Fig.7. (a) Input stream of data versus Received bit stream
(b) Eye diagram of the received data versus wrapped time

VI. CONCLUSION

The groups participating in the race for the ultimate flexible, low-loss, high-power, and maximum reliability are in constant search for new combination of fabrication materials and methods. Although there are some types of WG's which found their way to the medical laser commercial market, the race is not yet over and there is still a lot to improve. The perfect WG is not yet introduced.A consistent dedicated research is undergoing in order to achieve the desried results in the field of optics.

VII. ACKNOWLEDGMENT

Words are often too less to reveal one's deep regards .An understanding of the work like this is never the outcome of the efforts of a single person. I take this opportunity to express my profound sense of gratitude and respect to all those who helped me in this duration of entire dissertation. First of all, I would like to thank the supreme power, one who has always guided me to work on the right path of the life. Without his grace this would never turn into reality. I would like to express my deep sense of gratitude toward Ms. Geetanjli Ralh, Assistant Professor, Lovely Professional University, Phagwara who provided me all facilities and resources required for this thesis work. I would also like to thank all the faculty of the department and my friends who helped me in this work directly or indirectly.

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AUTHOR'S PROFILE

Harvinder Singh Josan
Pursuing Masters in Electronics and Communication at Lovely Professional University. Worked as a Technical Associate in Mainframes at Satyam Computer Services for 2.5 years [2007-2009] Worked as a Lecturer at Punjabi University, Rampura Phul, Bathinda for 9 months before commencing the Post Graduation degree. Certified in VLSI Design Technology at Semi-Conductors Complex, Mohali, and Punjab, India.
Contact: +919256671708

Jaspal Singh
Pursuing Masters in Electronics and Communication at Lovely Professional University. Post Graduate in Physics and currently pursuing M.Tech in Electronics & Communication.
Contact: +919878256599