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STUDY OF FIBER OPTICS IN THIN OPTICAL FIBER FOR THE ENHANCEMENT AND APPLICATION IN IMAGE PROCESSING

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Abstract: Image processing is very important and interesting field of research in the area of biomedical engineering, microscopy and optical technologies. Fiber optics nowadays play an effective and meaningful role in the field of image processing. The fiber optic in vivo imaging is still an important field of interest for the chemical sensing and spectroscopic interests. Fluorescence imaging using fiber optic technology has also been reported in recent past. Even medical imaging technologies need a large scale improvement for the better diagnostics and clinical management. Fiber optics has large scope in this area of improving those imaging qualities. In this paper, the study of such optical fibers and their properties which can directly be used for better imaging purpose are discussed. Different parameter studies have been carried out to ensure a better performance and at the same time the study also indicates the effect of the parameters in structural variations. A detailed study is made about the dependence of electric field intensity and optical field intensity on various diameters of the optical fibers used for simulation.

Key Words: Fiber-optics, Optical-fiber, Image processing

1. INTRODUCTION

Medical imaging is a technology which improves the pathological management of disease as well as diagnosis. Various technologies such as magnetic resonance imaging (MRI), ultra-sonography (USG) and computed tomography (CT) have tremendous impact in research, medicine and clinical practice. Fibre optic fluorescence imaging has contributed in this field to a great extent[1-2]. Optical fibers that are used in biomedical applications should have high stability and reliability for accurate diagnostic results and it should be safe for patients. The advancement of various optical methods used in modern era of medical fields like diagnostics, surgery and therapy has encouraged the growth of research of optical properties related to biological tissues. Effectiveness of laser treatment depends on propagation of photon and also fluence rate distribution in tissues that are exposed to light [3] so this optical imaging is a better option. In this paper, studies have been done on various parameters of optical fibers to find out the most efficient results in each case so that they can be used for various image processing techniques applied in various diagnosis and treatment. Hence it would contribute a notable advancement in modern medicine by getting accurate results of all biomedical imaging. The treatment of any disease solely depends on the

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diagnosis of that particular disease. So the proper and accurate diagnosis is the essential and foremost requirement in any case. The efficiency of the optical fiber determines the best diagnosis.

2. BRIEF REVIEW OF PREVIOUS WORK

Researches have been carried out by countries all over the world to develop networks that would be very efficient for global communication purposes. There are many advantages like attenuation, interference and bandwidth characteristics of optical fiber systems over conventional core based communication systems. Optical Fiber allows clearer, faster and more efficient communication in comparison to copper cables. The characteristics of optical fiber are of two types-liners and nonlinear. Attenuation, polarization mode dispersion, optical signal to noise ratio and chromatic dispersion are some of the linear characteristics. On the other hand, self-phase modulation (SPM), Stimulated Brillouin Scattering (SBS), four wave mixing (FWM), cross phase modulation (XPM) and stimulated Raman Scattering are included in nonlinear characteristics. They are controlled by several parameters like bit rates, power levels and channel spacing. In the recent past work has been done on fiber lasers for nonlinear bio-imaging. Attractive features of fiber lasers are pointed out for biomedical imaging. Solid state femto second lasers have been already developed which proved to be the dominant light source for various applications. Research has been done on high performance sources suitable for nonlinear microscopy [4].Development has already been done on cost effective and easily used health care services by using point of care diagnostics. In the recent years various optical imaging systems have been developed on the basis of POC diagnostics [5]. Biomedical Imaging has been revolutionized by endoscopy. Experimental demonstration has been carried out on ultra-thin rigid endoscope on the basis of multimode optical fiber [6]. Work has been done on Optical Coherence Tomography with vertical cavity laser imaging human retina [7].Also in the recent past researches on imaging of human brain tissues, both tumorous and non-tumorous, has been done using Optical Coherence Tomography [8].

3. SIMULATION PROCEDURE

In order to choose materials, the process was started with optical fibre SM800 core and silica cladding and simulated the whole system using an optical fiber toolbox OFT2.1 in Matlab simulation software (version R2014a). The same geometry can also be simulated by using many other material combinations like silica, air, water or alcohols. The wavelength range of the light propagating through the optical fiber has been taken as 400 to 1000 nm.

4. RESULTS AND DISCUSSION

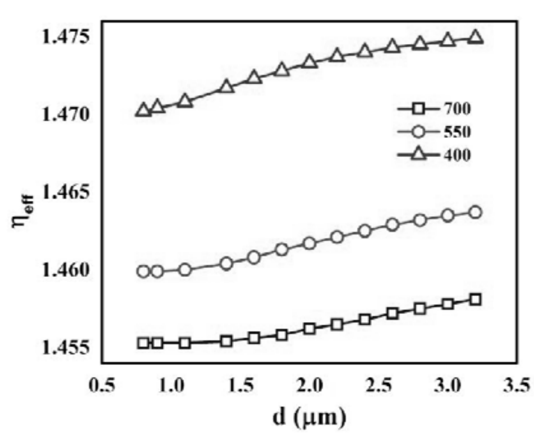

Figure 1. This plot shows the change in refractive index (η_{eff}) for different diameter (*d*) values of the optical fiber for different wavelengths of light.

The diameter of the core was selected starting from 0.5 micrometer up to 3.5 micrometer; it has been found that refractive indices increase with the increase of optical fiber diameter. The slope of the graph for blue color has medium slope whereas it is lowest for green color and highest for red color. The visible range of light signal has been considered, and a number of graphs showing electric field distributions of the propagating optical and optical intensity distributions for the same has been plotted which have been obtained with different values of diameter of the core, by keeping at first the value of wavelength at400 nm, then at 550 nm and lastly at 700 nm have been kept at fixed levels. In all the three cases, three separate set of results corresponding to various combinations of wide range of optical wavelengths and diameters of optical fibers have been shown for each case. i.e in Figure 2(a),Figure2(b),Figure 3(a),Figure 3(b),Figure 4(a) and Figure 4(b)

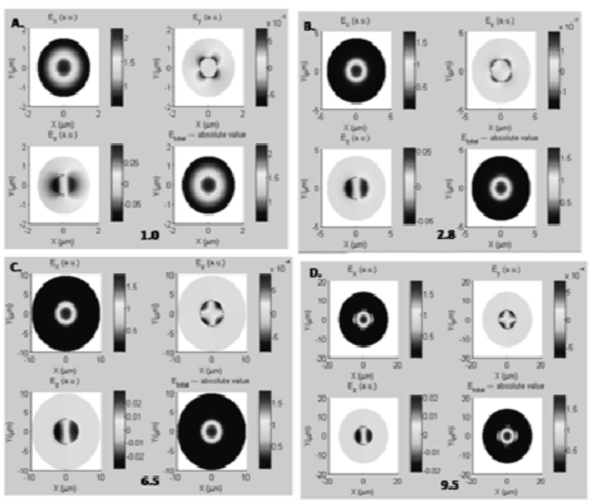

Figure 2(a). Electric Field distributions for (A) D = 1.0 µm, (B) D = 2.8µm, (C) D = 6.5µm, (D) D = 9.5 µm. Here D is the diameter of the core. The wavelength is 400 nm for all simulations.

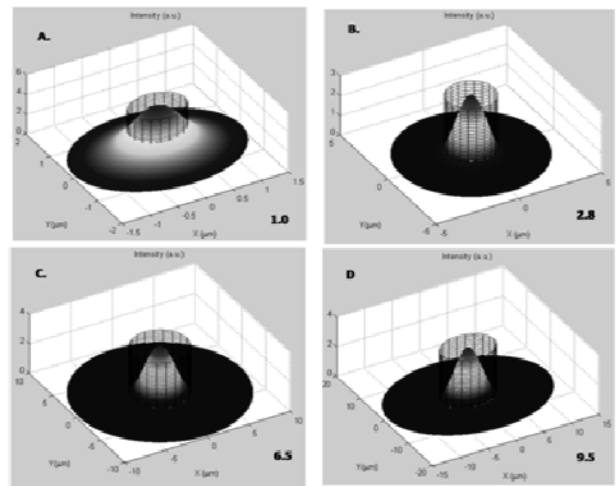

Figure 2(b). Optical field Intensity distributions Ez inside the optical fiber (A) D = 1.0 µm, (B) D = 2.8 µm, (C) D = 6.5 µm, (D) D = 9.5 µm. Here D is the diameter of the core. The wavelength is 400 nm for all simulations

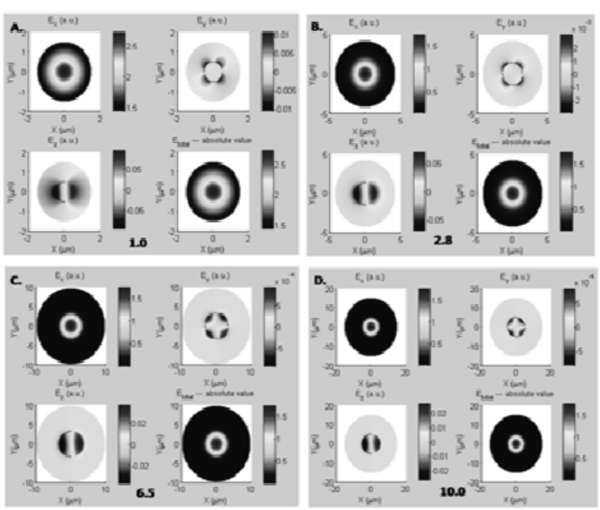

Figure 3(a). Electric Field distributions for (A) D = 1.0 µm, (B) D = 2.8 µm, (C) D = 6.5 µm, (D) D = 10.0µm. Here D is the diameter of the core. The wavelength is 550 nm for all simulations.

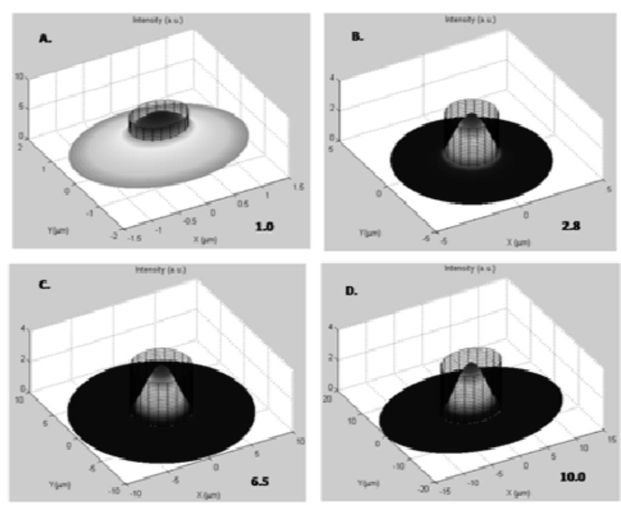

Figure 3(b). Optical field Intensity distributions Ez inside the optical fiber (A) D = 1.0 µm, (B) D = 2.8 µm, (C) D = 6.5 µm, (D) D = 10.0 µm. Here D is the diameter of the core. The wavelength is 550 nm for all simulations.

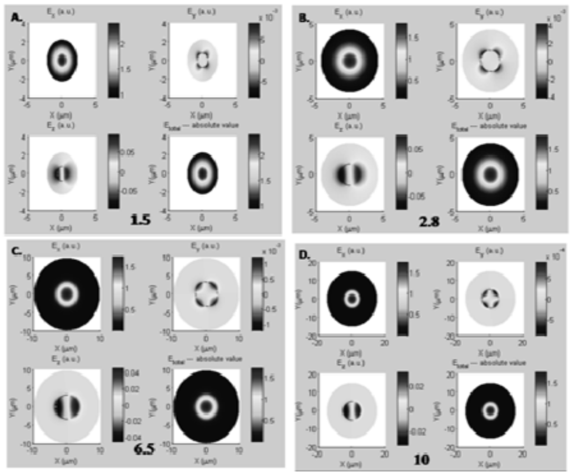

Figure 4 (a). Electric Field distributions for (A) D = 1.5μm, (B) D = 2.8 μm, (C) D = 6.5 μm, (D) D = 10.0μm. Here D is the diameter of the core. The wavelength is 700 nm for all simulations.

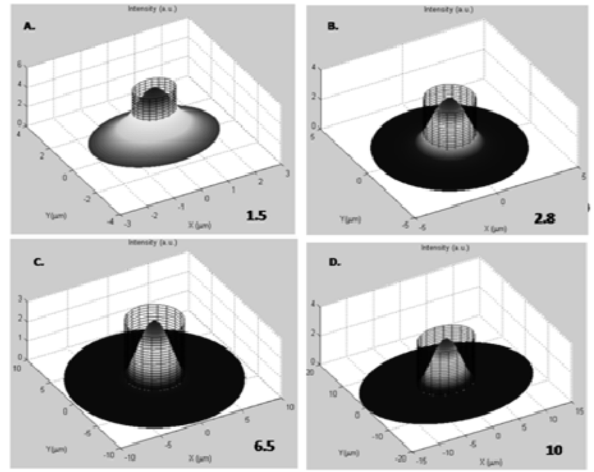

Figure 4 (b). Optical field Intensity distributions Ez inside the optical fiber for (A) D = 1.0 μm, (B) D = 2.8 μm, (C) D = 6.5 μm, (D) D = 10.0μm. Here D is the diameter of the core.

4.1 The wavelength is 700 nm for all simulations.

After simulating all the intensity distribution patterns for a set of different values of diameter, the maximum value of $E_{(z)}$ corresponding to each diameter has been found out for all the three cases i.e., for three different wavelength values(400 nm,550nm and 700 nm).

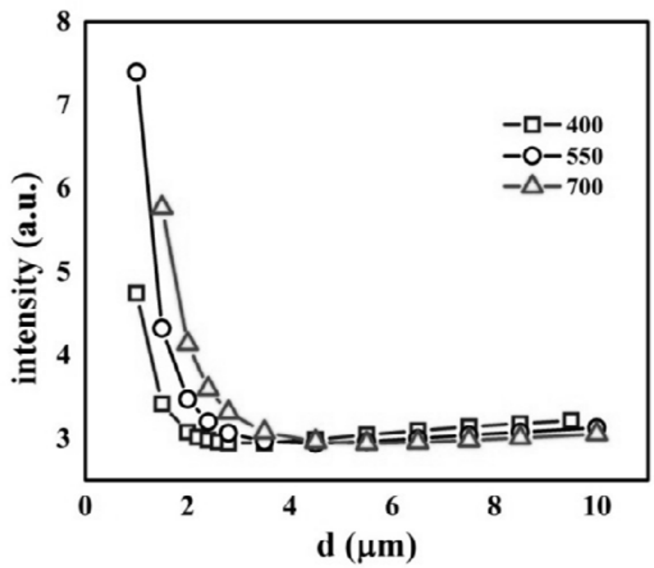

Figure 5. Plot of intensity vs. Diameter

Now taking all the maximum value of intensity patterns, a graph has been plotted against diameter which is shown in Figure 5. It displays the maximum of optical intensity E_z corresponding to each value of diameter combining the values of wavelength. It has been observed that the blue colour field intensity falls in the most fast rate while the rate of decrease of electric field for red colour, it is the least. This indicates that the red colour or infrared range of optical signal is the most viable option for optical communication while green colour poses a moderate existence for being an optical carrier signal. Regarding the application in digital image processing, in practice, whole electromagnetic spectrum can be utilised depending on the nature and quality of the image and the field of application. The colour is sensitive to act and rarely used in optical fibre communication. In digital image processing, Infra-red colour is used in satellite imagery, spectroscopy and in biomedical applications. The present study has conformity with the real life usages. Thus the simulation studies spanning over wide range of wave length and geometry of the optical fibre present some justification to the readers.

5. CONCLUSIONS

The present study is based on simulation but the dimension of optical fiber and material has yielded adequate tangible results. The study has made some notable bonding between the importance of optical fibers with the performance of imaging, image enhancement, and broad use of optical frequency bands in various sub domains of image processing like satellite imagery, infra-red spectroscopy and biomedical applications. The study is expected to put sufficient important input for further achievement regarding the dependence of importance of optical fiber and performance enhancement in digital image processing.

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