Australian Journal of Engineering and Innovative Technology, 5(2), 58-62, 2023

Publisher homepage: www.universepg.com, ISSN: 2663-7804 (Online) & 2663-7790 (Print)

https://doi.org/10.34104/ajeit.023.058062

Australian Journal of Engineering and Innovative Technology

Journal homepage: www.universepg.com/journal/ajeit

Investigation of the Dimensions of Making Brillouin Laser in Optical Fiber

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ABSTRACT

Optical fiber is a transparent material such as glass (silica) with plastic that can expel light from one end to the other, it has a much higher bandwidth than conventional cables which can be used for image data. It has the capacity to easily transmission of audio and other data with high bandwidth of up to 10 Gbps and above Nowadays optical telecommunications are the most important tools of data transmission due to their wider bandwidth, compared to copper cable, and less latency coppered to satellite telecommunications. In this paper, a fiber optic at speed of $^{6m}/_{min}$ is made of an isotropic optical fiber (with similar physical properties on all sides) prefabricated with a light sensitive core $Geo_{2-B-Sio_2}$.

Keywords: Fiber optic, Laser, Brillouin, Isotropic, Electro-optical modulator, Optica, and Application.

INTRODUCTION:

First people were thinking about using light to transmit information in the recent landfall experienced the propagation of light in the earth's atmosphere, but existence of various obstacles such as mud, dust, smoke, snow, rain, fog and so on, made it difficult to spread pure information in the atmosphere. Later, usage of pipes and canals were discussed to transmit information and guide the tour. The net inside these channels was guided by mirrors and lenses, but since it was very difficult to adjust these mirrors and lenses, this was also deemed impractical and was rejected (Caucheteur *et al*., 2008; Chamorovskiy Yu *et al*., 2017). Perhaps the first attempt in the journey is the evolution of the grid communication system which was developed by Alexander Graham Bell, who did it in the year 1880, two years after the invention of the optical telephone (photophone) or system that transmitted sound over distances of several hundred meters. The optical telephone worked by modulating reflected sunlight by lens vibrating (Awadala *et al*., 2020).

The receiver was a photocell. In this method the nets are spread in the air and therefore it was not possible to transfer information up to more than 200 meters, for this reason the Bell apparatus apparently worked but it was not commercially successful (Chryssis *et al*., 2005). The English Kago and Cockham firstly introduced the use of glass as a diffusion medium, they set out the speed about 100 Mbps and greater on glass diffusers to be achieved. The transfer rate was associated with severe energy attenuation. The two British researchers agreed to reduce the energy level up to less than 20 decibels. Although they failed to achieve their goal, then an American company (Corning Glass) succeed to achieved it with the invention of the laser beam fiber optic communication became possible in the early 1960 and in 1966 scientists theorized that light 3 ordinary, which was much more useful because fiber optic is much lighter and cheaper than copper cables and at the same time, they have transmission capacity of several thousand times greater than that of copper cables.

Optical fiber (usually silicon dioxide) which is used to transmit data by laser light. A fiber optic cable that is less than an inch in diameter is made up of a set of these fibers and can carry hundreds of Thousands of voice calls, hence commercially these fiber optics provide a capacity of 2.5 Gbps to 10 Gbps. Optical fiber is made up several layers, the innermost layer is called the nucleus. Its core is consisting of a fully reflective filament of pure glass (usually) cores of some cables are made up reflective plastic, which lowers the cost of construction. However, plastic core is usually not of glass quality and is mostly used to carry data over short distance. It is located around the core of the shell which is made up glass or plastic. The nucleus and the shell together form a reflective interface that causes light to travel through the nucleus to be reflected from the surface toward the middle of the nucleus where the two materials meet, this action is called the reflection of light to the middle of the nucleus or overall internal reflection (Faustov *et al*., 2012).

In the conventional type of fiber, diameter of core and shell together are about 125 microns (each micron equals one millionth of a meter), which is about the size of a human hair, depending on the manufacturer the protective multilayer shell consists of a coating, usually made of plastic. A hard-protective plastic coating forms the outer layer, this layer holds hundreds of different optical fibers that diameter is less than one inch. For production optical fiber, firstly its structure is created in a glass rod called a precursor made of silica and then in a separate process this stretched rod is turned into fiber. Since 1970 several methods have been used to make various types of precursors, most of which are based on the deposition of glass layers inside a pipe as a base. The main limitation is the low number of FBG embedded in a single way fiber, the low quality of FBG during the heating process, the low physical length of fiber with the FBG array and the significant linear loss. Recently, we shown the uniformity of FBG arrays (Faustov *et al*., 2016; Fotiadi *et al*., 2013) engraved on an Optica fiber by an excited laser at 248nm immediately during the design process, such a fiber contains more than 100000 FBG, and it is hundreds of meters long and has a reflectance spectrum of 0.2 nanometers. Our engraving technique, combined with the ability to control the fiber diameter during the design process, it allows us to produce FBG arrays with a distributed reflectance of hundreds of meters i.e., along the length of optical fiber such a new fiber device for many photonic applications, including optical signal processing distributed fiber sensing, and fiber lasers random useful. In this paper, fiber optic with a speed of 6 $\frac{m}{min}$ is made of an isotropic fiber optic (with similar physical properties on all sides) prefabricated with a light-sensitive core $Geo_{2-B-Sio_2}$. Multiple FBGs are engraved one by one in to the fiber immediately during the fabrication process through a fuzzy mask (1070nm mask background), and the outer diameter of fiber is precisely controlled by the prefabricated feed, which is linearly engineered with fiber length. The resulting fiber parameters are core diameter of about 6 *microns*, the difference between core and sheath refractive index is 0.025, cutoff wave length of about 1350nm (for outer diameter 125 microns), the length of the optical sample test sample is about 85 meters. Along the fiber, outer diameter changes linarly with the fiber length from 125 to 80 μm and then from 80 to 125μm, the total number of FBG engraved in the grave sample is about 4250. The sample fiber was tested with a frequency domain reflectometer (OFDR), analyzer (OBR-4600, Luna) (Fotiadi *et al*., 2022; Rizzolo *et al*., 2015) and a spectral analyzer (yokogawa AQ6370D). The outer diameter distributions of the tomb and the spectral analyzer (yokogawa AQ6370D) and the spatial peak of the reflected wavelength along the fiber length are shown by the black and blue curves respectively in **Fig. 1(a)**. We see a decrease in fiber diameter from 125 micrometers to 80 micrometers, causes simultaneous changes in peak reflectance wavelength from 1551 to 1548 nanometers. The small difference between two curves are explained by the natural heterogeneity in the precursor (refractive index fluctuations). reflection and transmission spectrum of light is shown in **Fig. 1(b)**, we see that reflection and transmittance coefficients are not uniform across the spectrum, and reflection coefficient at the shorter peak of reflected wavelengths is lower, which is related to smaller fiber optic diameter, this feature can be explained by the smaller part of the optical power that is emitted inside the smaller core and as well by the FBG engraved with lower efficiency for achieving the Brillouin laser in fiber, stretched with the FBG array (Soller *et al.,* 2005) a narrow-band laser source (approximately 100 Agilent KHZ) coupled to an erbium-doped amplifier (EDFA) which is adjustable between 1547 - 1553 nm, has been used as pump source. The array of sample fiber FBGS is connected with laser source via an optical spinner to broadband mirror with a reflectivity of about 85%, shown in **Fig. 2(a)**.

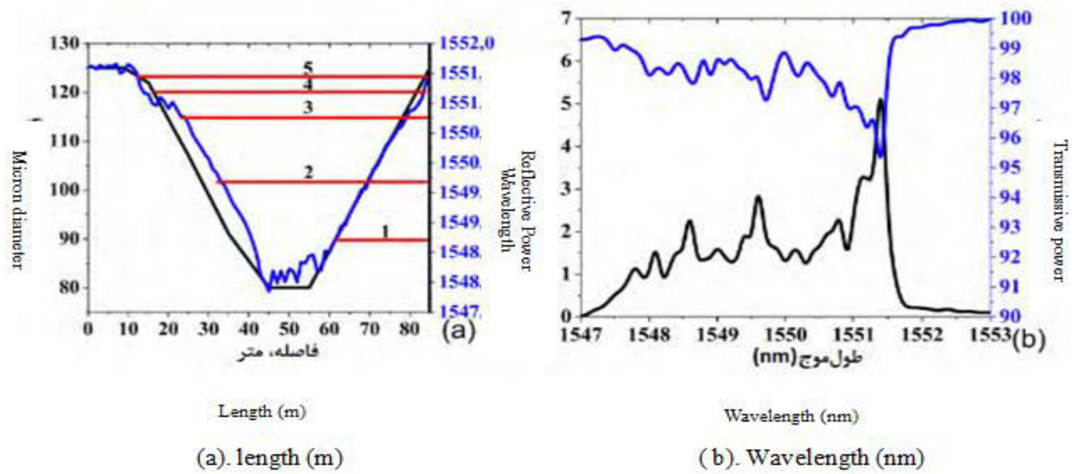

Fig. 1: FBG fiber curve drawn from outer diameter (black) and peak reflectance wavelength (blue). (a). Total reflectance spectrum (black) and transverse (blue) fiber; (b). The length of the Brillouin laser cavity at different pump wavelengths is indicated by red lines.

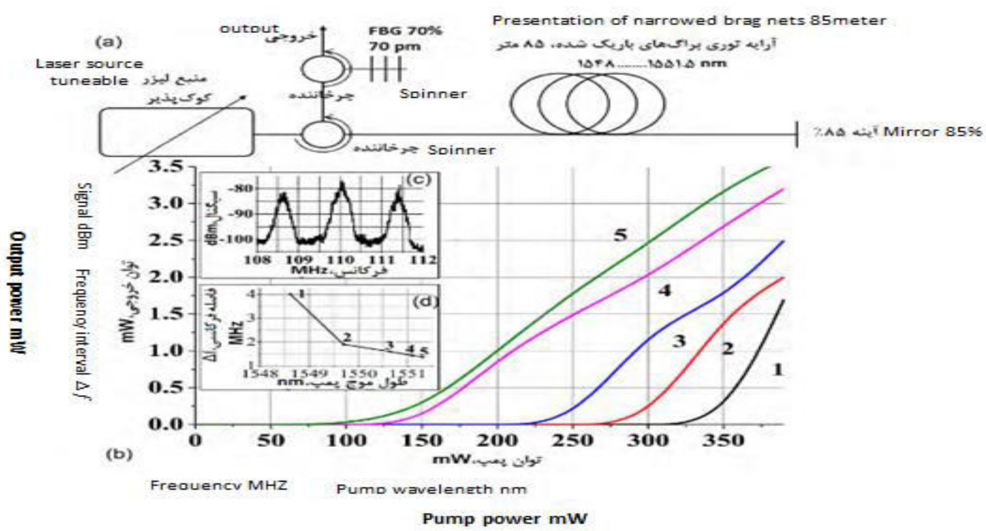

Fig. 2: Shows the dependence of the Δf period interval on the pump wavelength (a). Brillouin L cavity length values calculated from Δf measurements for different laser wavelengths (b).

Use of a broadband mirror enables the two-way pump of the Brillouin cavity and provides amplifications, not for rear direction also for the Brillouin-stokes waves as well. This two-way pumping significantly reduces the dissipation threshold output measured by the rotating output, also shifts relative to the pump wavelength of 0.09 nm and up to the SBS shift of 11 GHZ shown in **Fig. 1(b)** (Wang, 2014). An FBG with a narrow band (about 70 picometers) depending on spinner filters out the remaining pump power. Simulation to achieve Brillouin laser in stretched fiber with EBG array is given in (Zaitsev *et al*., 2016) due to the reflection back from the mirror and the redistribution of the fiber with the FBG array. The position inside the fiber, where an effective redistribution occurs is determined by FBG location which is obtained by matching the peak of the reflectance spectrum with the peak of Brillouin gain spectrum, which in turn is determined by the pump wavelength. Therefore, the effective laser cavity is limited between the cavity and this particular FBG. Adjusting the pump wavelength in range between 1548 - 1552 nm causes corresponding changes in the Brillouin gain spectrum and the point inside the fiber, where the most effective redistribution occurs, hence it leads to corresponding change in laser cavity length. The dependence of out-put power on the pump power for different wave-lengths of the pump is shown in **Fig. 2(b)**. The mini-mum and maximum laser thresholds are 75 and 320 mW at the pump wavelength of 1551.31 and 1548.62 nm respectively, which corresponds to longest and shortest laser cavity lengths as shown in **Fig. 1(a)**. A specific heterodyne self-laser spectrum recorded for the pump wavelength of 1551.31 nm shown in **Fig. 2(a)**. Spectrum by RF FSVR13 analyzer (Rohde & Schwarz) using Mach unbalanced Mach Zander interferometer with 25 km optical path, the electro-optical modulator is measured at about 110 MHz The recorded spectrum includes the central peak with a value of 100 kHz, also it includes several lateral peak bands with equal distance and with a period of $\Delta f = \frac{1}{3} MHz$. It can be seen, that this period is directly related to length of the Brillouin cavity in $= \frac{c}{2n} \Delta f$ which is determined by distance between the cavity mirror and a specific FBG according to peak Brillouin gain spectrum. **Fig. 2(b)** and **Fig. 1(a)** are shown by red lines; it can also see that they are in good agreement with the FBG peak wavelength distribution shown in **Fig. 1(a)**. The technology was developed to make thin fiber with an FBG array and was used to produce 85 mm specimens. Fiber has attractive properties for photonic techniques (optical information processing, fibrous temperature distribution sensors, random fiber lasers, distributive feed-back lasers). Brillouin laser was demonstrated for a semi-open cavity configuration that incorporates a new fiber optic structure and demonstrates the advancement of new fiber technology for Brillouin laser applications. **Fig. 2** Brillouin laser configuration (a). Characteristics of the laser power depend on the differ-rent wavelengths of the pump; (b). A specific RF laser spectrum of its own hydrodynamics recorded at pump wavelength (1551. 31 nm); (c). And the frequency interval of Δfon the wavelength of the pump; and (d). The wavelengths of the pump are 1548.62nm, 1549/7, 1550/65, 1551/0.9, 1551/31 nm in curves 1 to 5 respectively.

CONCLUSION:

The designers of third generation fibers considered fibers with least losses and scattering. To achieve type of fiber, researchers took advantage of minimum loss at 1550 nm with minimum scatter at 1310 nm designed a fiber that had a relatively more complex structure. In practice, with changes in the refractive index profile of single-mode fibers from the second generation, the minimum scattering in range of 1, 3 microns was transferred to range of 1,55 microns, thus the optical fiber with a different nature called fiber Ds. Made of D. S. F. Fiber. Fiber optics is best type of in-formation transmitter in today's era. Due to the flexibility of fiber optics and ability to send and receive light from them, is used in different cases such as digital cameras with special applications, medical photography, plumbing, etc. Due to many benefits fiber optics, these types of cables can have used in different cases. Most computer networks or telecommunications use fiber optics on large scale.

ACKNOWLEDGEMENT:

We are glad, that publishing our work in this journal, we are thankful to the editors and reviewer of journal.

CONFLICTS OF INTEREST:

Research is equally contributed by all authors and there is no conflict of interest between authors.

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Citation: Momand P, Niazai H, and Safi FRM. (2023). Investigation of the dimensions of making Brillouin laser in optical fiber. *Aust. J. Eng. Innov. Technol.*, **5**(2), 58-62.
https://doi.org/10.34104/ajeit.023.058062