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The Use of Taperred FBG Sensor for Characterizing Carbon Dioxide Gas

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ABSTRACT

Carbon dioxide gas or gas with a symbol is a combustion gas that can have a negative impact on the Earth and the health of living things. This article aims to know the meaning of carbon dioxide gas, Know the understanding and how fiber taper works, Know the use of fiber taper to detect optical properties in carbon dioxide gas, Know the advantages and disadvantages of fiber taper. This scientific paper uses the journal review method. The way a fiber taper works begins when light is directed at the fiber taper, which reduces the optical power of the light and produces a smaller critical angle. By reducing this critical angle, light exits the optical fiber and the intensity passing through the taper fiber is also low. This discussion uses the fiber taper region as a medium and changes the refractive index of the media around the taper, Fiber taper has several advantages, namely it is widely used in various photonic applications, reduces optical power loss, changes the size and shape of the light space in optical fiber, and can be produced with different profiles. In addition to advantages, optical fiber also has disadvantages, namely there is a possibility of power loss during the tapering process, prone to physical damage, requires complex handling, susceptible to temperature, pressure.

Keywords: *carbon dioxide gas, fiber taper, fiber optic*

1 Introduction

Earth has many hidden riches so it is not surprising that many events can occur beyond human ability or reason. This relates to the characteristics of something that causes the event to occur. In addition to humans, animals, and plants, something that cannot be touched or even seen by humans also has its own characteristics, such as gas one of them. On Earth there are various types of gases, ranging from those that are very beneficial to nature to those that are harmful. However, everything created must have a function or benefit without exception, depending on how and for what something is used.

Carbon dioxide gas or gas with an emblem CO_2 is a combustion gas that can have a negative impact on the Earth and the health of living things. Carbon dioxide gas is a major component of landfill and contributes to the greenhouse effect and can increase global warming worldwide. (Saraswati, 2012) Carbon dioxide gas is the largest composition of greenhouse gases in the atmosphere, at more than 75%. Carbon dioxide gas can absorb solar heat that is reflected back and has an impact on global warming. (Budi & Suparman, 2013) Although most of the waste is covered by earthen mounds measuring 10-15 cm in size to reduce disturbance of gases and odors, small amounts of these gases are constantly released into the atmosphere. (Herfi Rahmi, Aryo Sasmita, 2017)

The optical properties of carbon dioxide gas refer to its ability to absorb electromagnetic radiation at certain wavelengths, which can affect changes in temperature and climate. (Samtina, 2015) The most important optical property is its ability to absorb infrared radiation emitted by the Earth's surface and prevented from escaping into space. (Mohd Shah et al., 2018)

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To overcome all of the above, the properties of carbon dioxide gas, and various problems mentioned, such as global warming and other things, this article will discuss how to use fiber taper to detect the optical properties of carbon dioxide gas. This article will discuss the use of fiber taper to detect optical properties in carbon dioxide gas.

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2 Research Methodology

Carbon dioxide gas is a compound composed of one carbon atom and two oxygen atoms. (Ardhiany, 2019) Carbon dioxide gas is a greenhouse gas which plays an important role for infrared absorption (Astuti &; Firdaus, 2017)(Novi, 2020)(Saputri et al., 2022)(Ambarsari &; Tedjasukmana, 2011). Compounds have different capacities in each location. The higher the population in each location, the more pollution produced, so that the concentration of gas is also higher. The frequently changing and unstable climate also affects the concentration in the region.(Astuti &; Firdaus, 2017)(Gas et al., 2013) Carbon dioxide gas is a greenhouse gas that causes global warming which is one of the problems in the world. (Martuti et al., 2017)

Fiber taper Is an optical fiber whose diameter is smaller at certain points composed by plastic and glass fibers.(Yunus &; Arifin, 2018) This condition can be created by stretching the part and then heating the optical fiber. Taper fiber has elastic, lightweight but qualitative, and durable properties. (Gong et al., 2022) When light moves along fiber taper, the optical strength of light is reduced due to the reduction of the critical angle. This reduced critical angle causes light to radiate out of the optical fiber, resulting in intensity being transmitted through fiber taper is also inferior. Changes in the refractive index around fiber taper causes a critical angle change. Fresnell's law also affects the intensity of light. The Fresnell reflection principle for light at the interface between the optical fiber and the medium affects the intensity of the light guided in fiber taper . Based on both principles, this paper describes the use of fiber taper as a gas sensor.

The following is an overview of the working principle of the sensor using fiber taper.

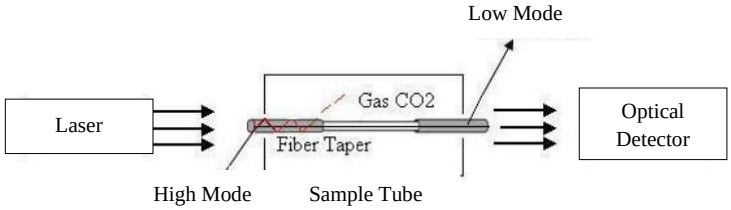

Figure 1. Working principle of sensor Tool

Qualitative methods are used in this scientific arya, with several steps, including:

1. Determine the background, formulate problems, and the purpose of making scientific papers.
2. Literature study, namely by collecting journals as a reliable source of data and information.
3. These journals are analyzed and concluded so that they are interrelated with each other to solve the formulation of existing problems.

3 Results and Discussion

3.1 Understanding and How Fiber Taper Works

Fiber optics is a science that is constantly evolving as an indicator of various physical parameters. One of the applications of fiber optic sensors that we will discuss is fiber taper which will detect carbon dioxide gas (Ni'mah, 2017). Fiber taper is an optical fiber with a smaller cross-sectional diameter (taper area). This condition can be created by stretching the part and then heating the optical fiber. The way a fiber taper works begins when light is directed at the fiber taper, which reduces the optical power of the light and produces a smaller critical angle. By reducing this critical angle, light exits the optical fiber and the intensity passing through the taper fiber is also low. Fresnel's law affects light intensity because light at the boundary between optical fibers and the environment affects the intensity of light guided in fiber taper, this process is related to Fresnel's principle of reflection. Fresnel's law of reflection is the law of observing the polarization properties of light by approximation and direction to the incident rays and reflected rays that form angles. (Physics &; Jember, 2016).

This discussion uses regions fiber taper As a medium and changes in the refractive index of the media around the taper, which is then associated with changes in the concentration of SDI around the taper in the form of gases that can affect fiber taper on his guided light. The optical detector detects changes in the intensity of the light guided in fiber taper. In this study, fiber taper The one used is homemade which has a taper size of 3.5, and 7 in mm units. For research, using a He-Ne laser, detector OPT 101, microvolt meter, tube for sample, and carbon dioxide in a tube with a concentration that can be varied by varying the pressure in the sample tube and generating output voltage data from the sample tube with a detector for carbon dioxide concentration. If the concentration of carbon dioxide is high, it will be the low output voltage price of the optical detector. Therefore, carbon dioxide gas sensors can be detected by fiber taper.

of use fiber taper as a gas sensor is the data of the relationship between the detector output voltage and the gas concentration shown in Figure 2.

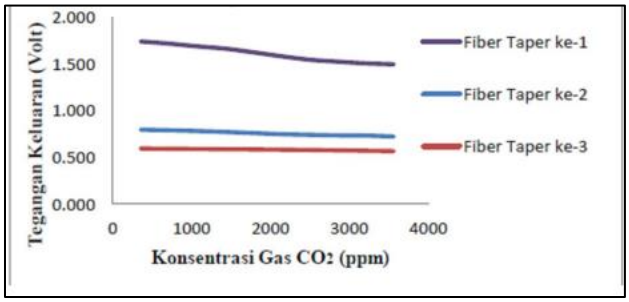

Figure 2. Graph of Detector Output Voltage to Gas Concentration

Information about the relationship between voltages Output The detector and gas concentration are shown in Figure 3, Figure 4, and Figure 5. Fiber taper 3 mm has the equation $V = -8 \times C + 1.7725$ in figure 3, for 10^{-5}fiber taper 5 mm has a linear line equation that is $V = -2 \times C + 0.8055$ in Figure 4, and with 10^{-5}fiber taper 7 mm has a linear line equation that is $V = -9 \times C + 0.6$ in Figure 5. 10^{-6}.

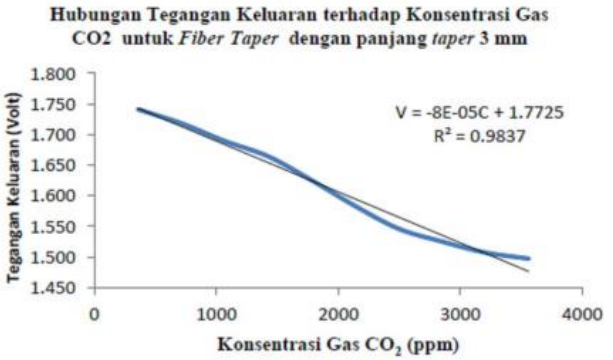

Figure 3. Linearity Graph og Detector Output Voltage Relationship to Gas Concentration for 3 mm Fiber Taper

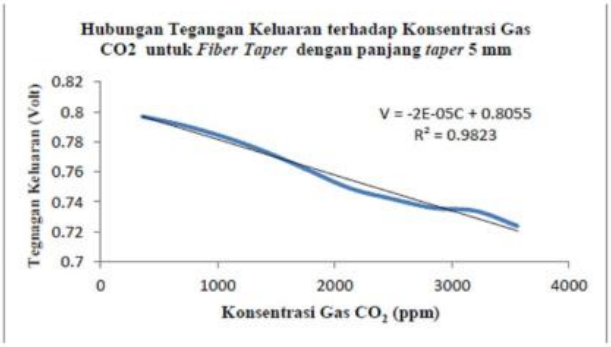

Figure 4. Linearity Graph of Detector Output Voltage Relationship to Gas Concentration for 5mm Fiber Taper

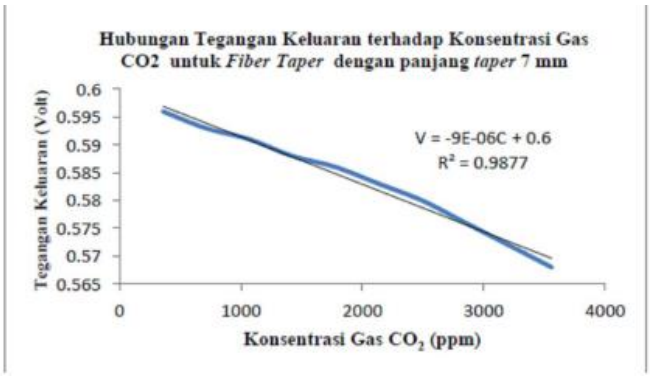

Figure 5. Linearity Graph of Detector Output Voltage Relationship to Gas Concentration for 7 mm Fiber Taper

Each length fiber taper is 3.5, and 7 in mm. The smallest change in gas concentration detected (dissolution) along each length of the pointed fiber is also of equal value, i.e. 356.19 ppm. For more detailed information, the characteristics of gas sensors with Fiber Cones can be seen in the following table.

Table 1. Gas Sensor Parameters using Fiber Taper

Taper length(mm)	The smallest detectable change in gas concentration (ppm)	Detection range (ppm)	Linear Area	Sensitivity (V/ppm)
3	356.19	356.19 – 3561.9	356.19 – 3561.9	8×10^{-5}
5	356.19	356.19 – 3561.9	356.19 – 3561.9	2×10^{-5}
7	356.19	356.19 – 3561.9	356.19 – 3561.9	9×10^{-6}

3.2 The Use of *Fiber Taper* to detect optical properties in carbon dioxide gas

To determine the shape of an optical property of carbon dioxide gas, the principle of changing light through the form of optical fibers is needed. Common steps to follow when using fiber taper To detect the optical properties of gases are as follows: (Waluyo, 2016)

1. Fiber taper can be made to heat and pull ordinary optical fibers that will produce fibers with gradually changing diameters. The wider end of the fiber will serve as the light input, while the narrower end of the fiber will serve as the output.
2. The detection system should consist of a light source that can be installed at the input end of the fiber taper and a light detector mounted at the output end of the fiber taper. The light detector will receive light that has interacted with the gas along the fiber tape.
3. System Alignment: Ensure that the light source and light detector are properly attached to the fiber taper. This will ensure that light can travel efficiently through the optical fibers. Light scattering in optical fibers is caused by differences in core refractive index and cladding which causes internal light reflection.
4. Interaction with Gas, fiber taper containing light is passed through a chamber filled with gas. When light passes through these gases, there will be interactions between gas molecules. Gas molecules will absorb some light with a certain wavelength.
5. Modulated Light Detection, Light interacting with these gases will escape through the output of the fiber taper and go to the detector. Light detectors receive light modulated by interaction with gases. Changes in the intensity of light detected by the detector will correlate with the amount of gas present in the chamber.

3.3 Advantages and disadvantages of using *Fiber Taper*

Here are the advantages and disadvantages of use: fiber taper (Aminah et al., 2016)

1. Advantages of using fiber taper
   a. Fiber tapers are widely used in various photonic applications. For example, the use of fiber optic sensors with fiber tapers is fast, very inexpensive, sensitive, and allows detection of biomolecules without labels.
   b. Fiber tapers can reduce optical power loss because their profiles allow light to be transmitted efficiently from larger fibers to smaller fibers. This is useful in applications where low power loss is critical, such as in long-distance fiber optic communication systems.
   c. Fiber tapers can change the size and shape of the light chamber in optical fibers. This allows light to be properly copied from the fiber to other optical devices such as detectors or lasers. Fiber tapers are also used to connect optical fibers to light sensors or laser devices in laboratories and to test optical communication systems.

d. Fiber tapers can be manufactured with different profiles depending on application requirements. This allows meeting the special requirements of flexible and adaptable models, such as single-mode or multi-mode transfer, or for optimization of power transmission and light efficiency.

2. Disadvantages of using fiber taper
   a. During the *tapering* process, there is a possibility of additional power loss due to thermal or geometric effects. Failure to place the cones carefully can result in unwanted performance losses and reduce system efficiency.
   b. *Taper fibers* have a smaller size at the ends, making them more susceptible to physical damage. The fibers concentrated at the end of the taper are easily broken and damaged, so careful handling is needed.
   c. The process of making *fiber taper* requires a high level of technical knowledge and specialized equipment. This can make *fiber taper* production complicated and take longer than standard fiber optic production.
   d. *Taper fibers* can be sensitive to temperature, pressure or other environmental changes. These variations can affect *taper performance* and result in variations in power transmission or light efficiency.

When using *fiber taper*, it is important to consider these advantages and disadvantages, as well as the specific needs of the application, to ensure they will be used as needed and as a performance optimizer.

4 Conclusion

Fiber taper is an optical fiber with a smaller cross-sectional diameter (taper area). This condition can be created by stretching the part and then heating the optical fiber.

The way a fiber taper works begins when light is directed at the fiber taper, which reduces the optical power of the light and produces a smaller critical angle. By reducing this critical angle, light exits the optical fiber and the intensity passing through the taper fiber is also low. Fiber taper is also affected by Fresnell's law. To determine the shape of an optical property of carbon dioxide gas, the principle of changing light through the form of optical fibers is needed.

Fiber taper has several advantages, which are widely used in various photonic applications, reduce optical power loss, change the size and shape of the light chamber in optical fibers, and can be produced with different profiles. In addition to advantages, optical fiber also has disadvantages, namely there is a possibility of power loss during the tapering process, prone to physical damage, requires complicated handling, is susceptible to temperature, pressure, and other environmental changes.

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