Design of New Multilayer Waveguide Sensor Based on Computer Software

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Abstract: At present, the optical waveguide biochemical sensor that has been put into commercial use adopts a flat plate structure, and the evanescent field in the cover layer is used in the test process, and the test object is the effective refractive index in the cover layer. This kind of acceleration sensor has low optical coupling efficiency and poor lateral resonance resistance, which reduces its frequency response range and large signal distortion, and can not meet the high-frequency and high-precision seismic exploration. In this paper, a new multi-layer waveguide sensor is designed by using computer software technology to collect the information of objects through the network. It has stable performance, good lateral resonance resistance, high degree of integration and small volume, and can meet the requirements of high-frequency and high-precision seismic exploration. The nano-film on the surface of optical waveguide is characterized, and the advantages of porous sensitive film are verified compared with dense sensitive film. The influence of relative temperature on the sensor is studied. The higher the relative temperature, the more severe the influence. And can work reliably in the harsh flammable and explosive environment, which is expected to solve the assembly difficulties and long-term stability problems encountered by traditional optical fiber sensors in miniaturization and mass production.

1. Introduction

Optical sensing technology can detect multiple physical quantities such as force, displacement, and acceleration. Optical acceleration sensors that utilize various optical effects to achieve acceleration detection have advantages such as high sensitivity, wide frequency band, and wide dynamic range. The structure of the optical waveguide biochemical sensor that has been commercialized currently is a flat plate structure. During the testing process, the evanescent waves in the cover layer are used, and the test object is the effective refractive index in the cover layer. This type of acceleration sensor has low optical coupling efficiency, poor lateral resonance resistance, which reduces its frequency response range, and high signal distortion, making it unable to meet the requirements of high-frequency and high-precision seismic exploration [1]. Meanwhile, due to the use of crystal devices, the overall structure of the sensor is large and its stability is poor. Produce sensitive thin films doped with indicators on the surface of optical waveguides. Because different sensitive reagents exhibit different optical sensitivity characteristics in optical waveguides, the type of sensitive reagent can be changed to detect different gases [2].

Most multi-layer optical waveguide sensors use evanescent waves as probes, which interact with the sensitive layer, causing changes in the amplitude and phase of the guided wave light. The length of the interaction area reaches several centimeters, resulting in a significant improvement in the sensor sensitivity of this structure [3-4]. The sensitivity of physical and chemical quantities of substances in the coating layer depends on the intensity distribution of evanescent waves, which is completely dependent on the optical size of the sensor. The emergence of wireless sensor networks has produced a new mode of information acquisition and processing. Micro sensor nodes can be randomly or angrily deployed in the target environment, achieve self-organization through wireless communication, acquire information about the surrounding environment and work together to complete information acquisition tasks [5]. However, the area of interaction between guided wave light and sensitive substances is almost limited to the surface monolayer of the sensitive film, which limits the improvement of sensitivity.

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Traditional sensors of this type have a substrate with a higher refractive index than the coverage layer, but most of the dissipated wave energy is in the non working region. This article uses sensor technology to accurately identify items, and effectively applies sensor technology to accurately identify items. Then, through computer technology and the Internet, information is collected on items, enabling the construction of a data management system in the Internet of Things. A new type of multi-layer waveguide sensor is proposed by utilizing computer software technology to collect information about objects through the network. It has stable performance, good lateral resonance resistance, high integration degree, and small size, and can meet the requirements of high-frequency and high-precision seismic exploration [7]. And it has unique advantages such as reliable operation in flammable and explosive harsh environments, which is expected to solve the assembly difficulties and long-term stability problems encountered in traditional fiber optic sensors towards miniaturization and mass production.

2. Sensitivity Theory of Multilayer Waveguide Sensors

In the waveguide, there are two modes of guided light: transverse electric mode and transverse magnetic mode, with $m = 0,1,2,\cdots$ being the mode order. Another characteristic value is the effective refractive index N. Sensors have two working modes, single sensing and surface sensing, depending on the measured object. By effectively integrating the sensor principle into computer technology, sensors can be read and written through the application of microcontrollers. Previously, sensing elements were used to reduce the thermistor value through thermistor sensing. In previous analysis of surface mode sensing theory, It is assumed that the thickness of the attachment layer on the covering layer is much greater than the wavelength of the light used for testing [8]. In the case of positive symmetry, this assumption is valid due to its detection range of only 100-200 nm, but it may not be applicable to antisymmetric structures. The waveguide force diagram of the optical waveguide acceleration sensor is shown in Figure 1.

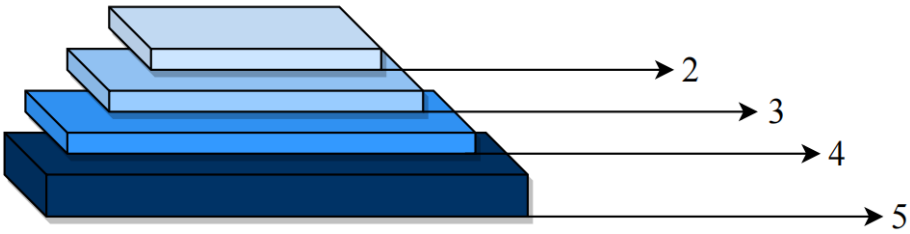

Figure 1 Waveguide Stress Diagram

The evanescent waves transmitted in the waveguide will penetrate into the nano sensitive film and interact with the sensitive film. When a danger signal appears in the monitored environmental data, it is necessary to know the specific location of the node that sends the signal in order to avoid accidents. Due to the significant characteristics of this type of semiconductor thermistor as a sensing element, it is the most widely used sensor. Semiconductor thermistors have three characteristics: small volume, high sensitivity, and high accuracy, which are superior to other types of temperature sensors. Moreover, the production process of this type of sensor is simple and feasible, and the cost is low [9].

Temperature measurement is a common application, and the requirements for temperature control in specific production processes are very high, such as electronic products. When computers are used for temperature monitoring, they will send out an alarm signal in a timely manner when the temperature is not within the specified range, and there are strict requirements for temperature control in the production process. Usually, temperature sensors are regarded as parameters of computer software to control the program flow of the computer. They have great significance in industry and are widely used. Their chips are composed of three parts: temperature sensing, analog-to-digital conversion, and communication interfaces. However, in the subsequent stages, corresponding signal processing is required, and thermistors do not have good stability, cannot accurately measure temperature changes, and cannot effectively detect the accuracy of the entire system. Only after the node itself has determined its location can the specific location of the event detected by the sensor node be determined.

When the thickness of the guided wave film is thin enough to approach the cutoff thickness d_c, the effective refractive index approaches $n_{\max}$. When the planar waveguide is used for sensing, the detected quantity is the effective refractive index N, and its variation ΔN is the sensing response relative to the change of waveguide environment. When the waveguide works in a single sensor mode and is used for micro-refractive index timing, the sensitivity of the sensor can be defined as:

$$s(n_c) = \partial(N) / \partial(n_c) \quad (1)$$

When the waveguide is used as a surface sensing mode, the test object is the thickness of the adhesion layer, and its sensitivity can be defined as:

$$s(a) = \partial(N) / \partial(a) \quad (2)$$

When the concentration of ammonia gas around the sensitive film is stable, the sensitive film combines with ammonia gas to reach a balance, and when it combines with ammonia gas adsorbed into the pores, its color changes, and the degree of discoloration is related to the amount of ammonia gas adsorbed into the pores, resulting in its different absorption of evanescent field [10]. The absorption of guided light will not change much, and the output light intensity will be stable.

3. Design of a Novel Multilayer Waveguide Sensor Based on Computer Software

3.1. The design of waveguide materials has been determined

Modern society has entered the information society. Semiconductor device technology has developed rapidly. The use of modern information technology has injected new vitality into traditional industrial production. Computer software development has been applied in multiple aspects with the development of computer technology. Computer software technology includes tool software development in the upper layer of computer operating systems and embedded software development based on hardware platforms. Sensor network is a distributed data collection tool, with each node having data collection capabilities. A base station is generally a node with strong processing power. The collected data, after fusion and forwarding, will be sent to the base station for processing. The control commands for the network are also sent to the network by the base station. The program design of single-chip microcontrollers based on simple processors also belongs to the category of software development. The design goal is to maintain a sensitivity range of 0.2 to 0.9 during the real-time testing process when the sensor is used as a micro refractive index meter. The relationship curve between width boron and thickness d in a single-mode strip waveguide was solved through programming, as shown in Figure 2. According to the actual process conditions, $\omega = 6.7\mu m$ and $d = 2.5\mu m$ are selected. The width of the waveguide is $6.7\mu m$ and the thickness is $2.5\mu m$ pm.

When the sensor is subjected to an acceleration in a certain direction, under the inertial force in that direction and the gravity perpendicular to that direction, the waveguide generates tensile and compressive stresses corresponding to the acceleration direction and proportional to the inertial force generated by the acceleration. The effective refractive index N can be obtained by solving the characteristic equation based on different operating modes. Single sensing modes include:

$$\left(n_f^2 - N^2\right) = m\pi + \arctan \quad (3)$$

The surface sensing modes include:

$$\left(n_f^2 - N^2\right) = m\pi + \tan^{-1} \quad (4)$$

The single-mode transmission analysis of waveguides shows that the thicker the thin film and the shorter the wavelength of the light, the greater the refractive index difference between the waveguide layer and the substrate. Temperature measurement is the most common application. Temperature control is required in production processes. Some electronic products have high requirements for temperature environment, and the normal operation of devices also requires appropriate temperature, For example, computers have temperature monitoring functions for CPUs. When the temperature exceeds a certain range, an alarm will be triggered. Standard computer rooms require an ambient temperature range of 23 to 25 ℃. The more modes can be maintained by a flat waveguide, and the cutoff thickness increases with the increase of optical wavelength and modulus.

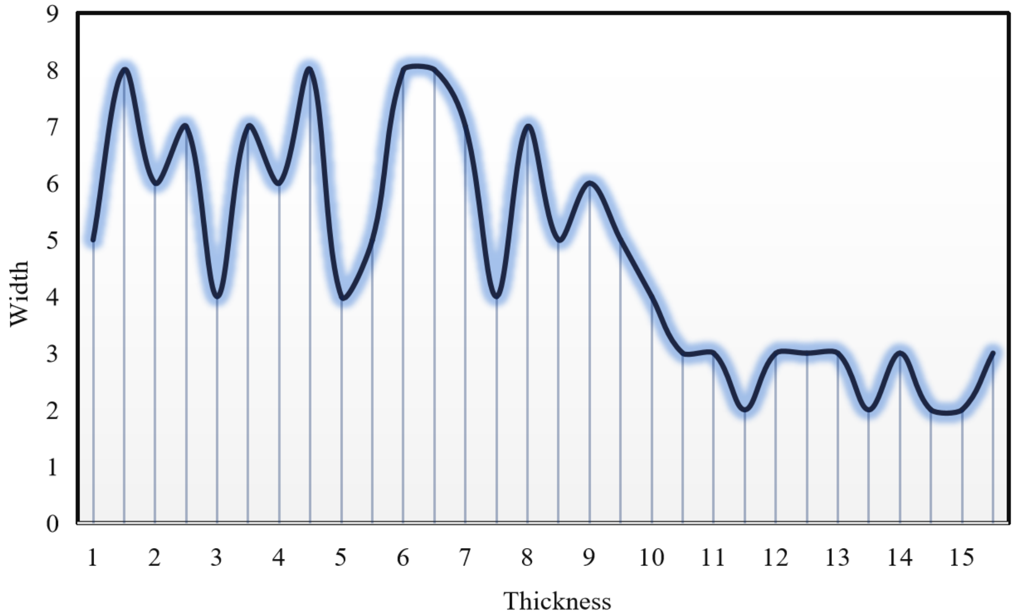

Figure 2 $\omega - d$ Single Mode Relationship Diagram

3.2. Design under the condition that the refractive index of measurable coating is determined

The closest combination of sensor principle and computer software technology is to read and write the sensor by using single chip microcomputer or embedded chip. The traditional temperature detection uses thermistor as temperature sensitive element, which is low in cost, but requires subsequent signal processing circuit. And the reliability of thermistor is relatively poor. The acid-base indicator in the sensitive film absorbs almost zero light with the selected wavelength of 633nm. When it meets ammonia molecules, its color will change from yellow to blue, and it has the largest absorption for the selected light with the wavelength of 633nm. The accuracy of measuring temperature is low, and the accuracy of the detection system is also poor. The product of the reaction between ammonia molecules in the adsorbed porous and the sensitive film interacts with the evanescent field, which leads to the change of output light intensity.

Because the surface of a certain sensitivity is smooth and monotonous, and the values of different sensitivities are unique. The closest combination of sensor principle and computer software technology is to read and write the sensor by using single chip microcomputer or embedded chip. The traditional temperature detection uses thermistor as the temperature sensitive element, and the optical phase will change when the light wave passes through two waveguides. However, other acceleration components that are not in the measured acceleration direction produce tensile and compressive stresses in the same direction on the waveguide, and the electrical signals generated by it are eliminated by signal processing. Thermistor has low cost, but it needs subsequent signal processing circuit. And the reliability of thermistor is relatively poor. The accuracy of measuring temperature is low, and the accuracy of the detection system is also poor. Therefore, only the acceleration in the measured direction can be detected.

4. Conclusions

The combination of software development and practical applications is meaningful. Users will meet their actual needs in programming. Developing computer automation programs can improve production efficiency and bring more convenience to people's lives and work. This article will design a new type of multi-layer waveguide sensor based on computer software. The application of sensor technology can make perception ability higher than sensory ability. Therefore, we often find the existence of sensor technology in our daily lives, which has become a member of environmental detection, popularization of the Internet of Things, and automation industry. A new type of multi-layer waveguide sensor is proposed by using computer software technology to collect information of objects through the network. It has stable performance, good lateral resonance resistance, high integration degree, and small size, which can meet the requirements of high-frequency and high-precision seismic exploration. The nano thin films made on the surface of optical waveguides were characterized, and the advantage of higher sensitivity exhibited by porous sensitive films compared to dense sensitive films was verified. The influence of relative temperature on the sensor was studied. The higher the relative temperature, the more severe the impact. In order to maintain the sensitivity between 0.2 and 0.9 during the real-time process of using the sensor as a micro refractive index meter, the constraint relationships between various parameters were analyzed based on different design requirements.

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