H2S Gas Detection Based On Optical Waveguide

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Abstract. The presence of H2S (hydrogen sulphide) gas in oil and gas exploration can give rise to critical safety problems because of its corrosivity and toxicity. In order to protect people and equipment, there is a need for a real-time,remote and reliable seneor that can detcet the concentration of H2S gas. The best way to monitor H2S gas concentration is optical-electrochemical sensor technology. At present, the optical-electrochemical method detects the H2S gas concentration. Yet this detector has adequated low sensitivity and weak detection signal which can not be used for remote transmission. To overcome this problem, this paper presents a new optical-electrochemical method based on optical guided wave field. The method is that H2S is combined with specific chemicals and they set off a chemical reaction, which changes the propagation characteristic of light. So the concentration of H2S gas is detected by detecting the change of optical guided wave field. This method improves the detection sensitivity and SNR (signal to noise ratio). The method provides theoretical basis for monitoring the H2S gas concentration over a large area and long distance.

Introduction

H2S is a highly corrosive and poisonous gas,widely produced in the oil, chemical, steel and other production processes. Especially in the process of exploration and development of oil gas field, H2S gas leakage accident occurs easily. Because of the oil and gas fields are in the mountainous area in our country and complex terrain makes H2S gas leakage is difficult to spread and accumulate in the near field,which seriously threat to personnel security and corrode oil or gas equipment[1]. It is necessary to monitor the H2S gas concentrations in the oil and gas fields in real time and remotely.Formation of H2S gas detection network can achieve no omissions detection. Personnel can early detect and deal with H2S gas leakage[2].Due to the strong ability of fiber to resist electromagnetic interference and it can transfer large amount of information form detection network, the optical detection technology of H2S gas has become the key technology of the development of various countries. One of the most important H2S detection technologies is the optical-electrochemical method. It has many advantages, for example, the fast speed of electrochemical method, low cost, and Large amount of information, so it has become a research hotspot at home and abroad.

The H2S gas signal is extremely weak and low sensitivity at low concentration.When oil gas is explored and developed, the other acid gas associated with H2S gas will produce strong noise, and reduce the SNR of the signal. But the remote security detection requires the strong signal intensity of H2S gas and the high SNR to overcome transmission loss. Therefore, the key technology of low concentration of H2S gas detection is how to enhance the signal intensity of low concentration H2S gas, improve the signal to noise ratio and increase the detection sensitivity.

At present,The concentrations of H2S gas is detected by the electrochemical method, such as the iodine content method[3], the methylene blue method[4], the lead acetate reaction rate method[5], the detection tube ratio method[6], and so on. Electrochemical method has the advantages of fast reaction, small size and low cost. But the reaction between the gas molecules and the sensitive electrode can make the reference drift. At the same time, the signal of the electrochemical sensor is difficult to transmit in the severe working environment of the electromagnetic field. Optical-electrochemical method has advantages of electrochemical method and combined with the features of fiber, such as strong ability of anti-electromagnetic interference, remote transmission of large amounts of information, easy to constitute a light sensor networks,and so on. It is the key technology of the research at home and abroad[7].

Research method

Optical-electrochemical method based fibers. The method of detecting H_2S by optical-electrochemical method is that the fiber is combined with specific chemicals. The chemical material reacts with H_2S and changes the propagation of light in optical fiber. So the concentration of H_2S gas is detected by detecting the change of optical property, as shown in figure 1.

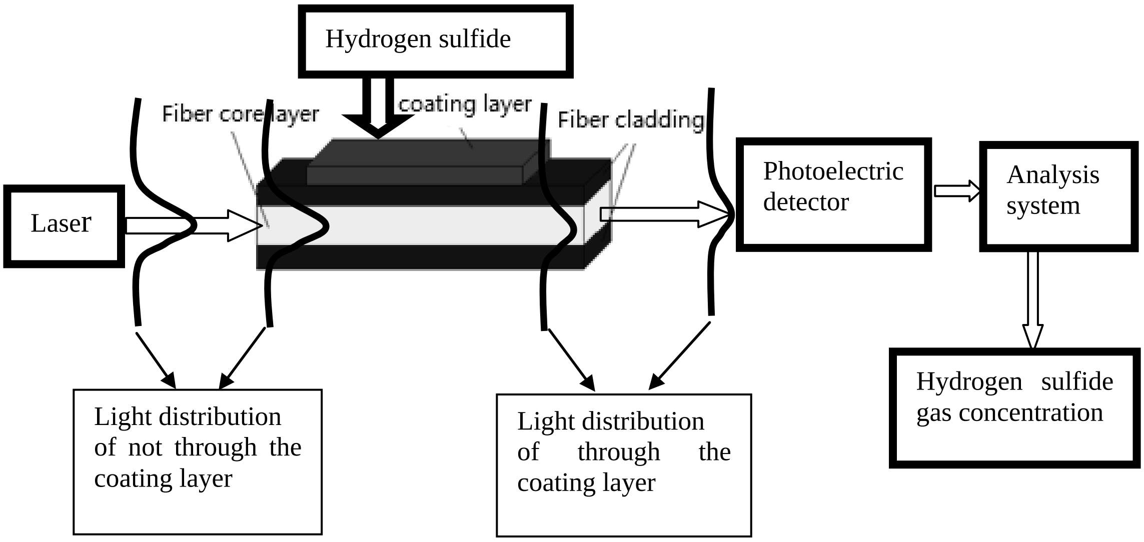

Figure 1 Detection of H_2S by optical-electrochemical method

The polyethylene amine oxide with $CdCl_2$ was coated on the coating layer. It will generate CdS after $CdCl_2$ reacting with H_2S. The fluorescence of CdS will change the light intensity of transmission in fiber. Therefore, H_2S gas concentration can be detected by detecting the change of light intensity. This method can realize the remote detection of weak concentration of H_2S gas[8]. However, owing to the diameter of the fiber being very small, the area of the fiber end surface of the coating is extremely small and it is hard to implement effective coating. H_2S gas reaction surface is too small,which leads to the sensor signal is extremely weak and difficult to detect.

Optical-electrochemical method based on guided wave field. To solve the above key technical problems, this paper presents a kind of optical-electrochemical method based on optical waveguide. In this method, the concentration of H_2S gas is detected by detecting the change of optical guided wave field. Compared with fiber, The optical waveguide fabricated by semiconductor integration technology is not restricted in the direction of optical transmission. The coating area can be greatly increased if the chemical material is coated in the length of the optical waveguide. It will solve the problem of effective coating and greatly increase the gas signal intensity, enhance the sensitivity, improve the SNR. The method provides theoretical basis for monitoring the H_2S gas concentration over a large area and long distance.

The concentration of H_2S was detected by the wave guide wave field change. Coating organic polymer on the optical waveguide layer, the chemical material reacts with H_2S and changes spectrum absorption characters of the coating layer. And then optical guided wave field is changed. Therefore, the concentration of H_2S was detected by studying the relationship between the spectrum characters of the coating layer and the concentration of H_2S gas and the influence of the refractive index of the coating layer on the light intensity distribution of the guided wave field.The whole detection system is shown in Figure 2.

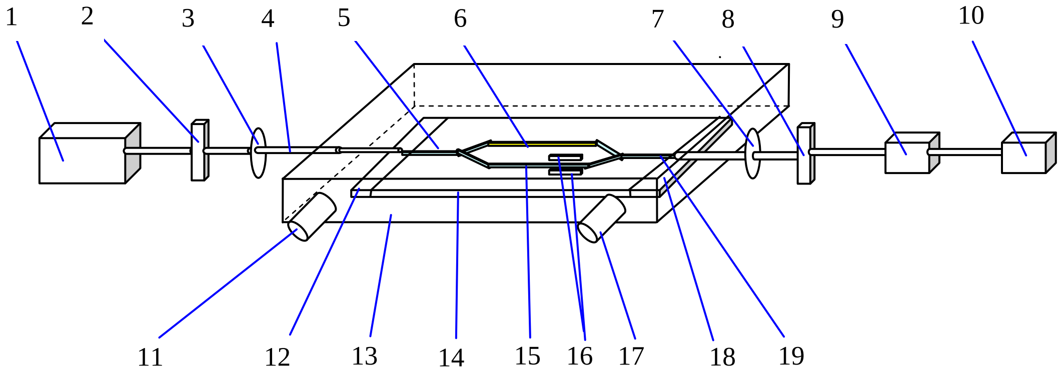

Figure 2 The detection system of H2S gas based on the change of guided wave field
1、Laser 2、Polarizer 3、Lens 4、Fiber 5、Branching waveguide 6、Polymer waveguide 7、Lens 8、Light analyze 9、Photodiode 10、Micro signal processor 11、Air inlet 12、The input coupling element 13、Gas chamber 14、M-Z waveguide interferometer 15、Straight waveguide 16、Waveguide phase modulator 17、Air outlet 18、The output coupling element 19、Branching waveguide

Laser 1 emits a certain wavelength of light and the light becomes linearly polarized light after the polarizer 2. The linearly polarized light is coupled into the gas chamber 13 by lens 3 and is transmitted in the chip of the M-Z waveguide interferometer 14 in the gas chamber 13. The H_2S gas that is measured circulates in the gas chamber 13 between the air inlet 11 and the air outlet 17. H2S gas of the polymer reacts with polymer waveguide 6, and the refractive index of the polymer waveguide 6 is changed. Thus, the intensity and phase of the guided wave field in the polymer waveguide 6 is changed. The light intensity of the change is output by M-Z waveguide interferometer 14. The light intensity of the change passes through lens 7 and partial detector 8, and then enter the photoelectric detector 9 and micro signal processor 10. The concentration of H_2S is obtained after signal processing.

Conclusions

In order to solve the problem of weak signal in optical-electrochemical method, the theory of optical integrated sensing technology based on optical waveguide is presented.This method increases the signal intensity and improves the SNR, and overcomes the weak problem of the signal. At the same time, the sensing network is easy to form because of the optical integration technology. This method can realize the safety detection of H_2S gas in the field of petroleum exploration and exploitation. It has the advantages of wide range and remote monitoring.Therefore, this research has the importantly scientific significance and the widespread application prospect.

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