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Process Design of Core Component of Optical Sensor for Ocean Monitoring

Jiahui Zhu[2,3], Yongquan Zhao[2,3], Jiangjie Shen[1,2,3,*], Shengjun Ji[2,3], Jiaan Cao[2,3]

[1]College of Marine Resources and Environment, Hebei Normal University of Science and Technology, Qinhuangdao Hebei 066600, China;

[2]Hebei Technology Innovation Center of Photovoltaic Module Manufacturing Equipment, Qinhuangdao Hebei 066000, China;

[3]Hebei Engineering Research Center of PV Module Encapsulating and Measuring Equipment, Qinhuangdao Hebei 066600, China.

*axnshilei@126.com

Abstract

Optical sensors are widely used in marine monitoring. The production of optical sensors in China is not high, and the cutting-edge products are basically dependent on imports. Therefore, on the basis of the existing optical sensor production process, the production process of light source and grating, the core components of optical sensors, is optimized. Based on the original LED production technology, the design and development of purple LED light source for water quality monitoring are completed to solve the problem of high power consumption and uneven irradiation of purple light source. PCF is used as material to make grating, and the process is optimized to improve grating accuracy and service life.

Keywords

Ocean Monitoring; UV-LED; Grating.

1. Introduction

Ocean is an important part of the development of countries in the twenty-first century, with the progress of science and technology, people gradually put their eyes on the ocean. The ocean contains a large number of biological resources and energy. The development of marine resources can not only promote economic development, alleviate energy shortage, but also highlight the level of science and technology of a country. With the development of marine economy and the increasing importance of marine security, marine monitoring has become an important direction for the research and development of countries around the world. The marine environment is affected by many factors and has high uncertainty, such as temperature, turbidity, chlorophyll, salinity, ocean current direction and velocity, which will affect the marine environment to a certain extent. Marine monitoring mainly relies on various sensors to measure the parameters and analyze the data back through the sensor carrier, and then obtain the hydrological conditions of specific sea areas. Sensor is the basis of modern ocean monitoring, which converts hydrological, meteorological and other environmental information into photoelectric information. It can be said that the history of modern ocean monitoring is the history of sensor technology. Different sensing principles can be divided into thermal sensitivity, photosensitivity, humidity sensitivity and force sensitivity [1]. Optical sensors based on photosensitivity principle have the advantages of non-contact and non-destructive measurement, high precision and anti-interference, so they are widely used in marine hydrological detection. Turbidity, chlorophyll, salinity and depth are mainly measured by optical methods, covering a wide range of

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types and comprehensive monitoring. With the development of ocean observation system, under the demand of long-term continuous observation of the marine environment and ecological environment, the United States, Japan, Canada and Germany have developed multi-parameter water quality measuring instruments, rapid response temperature sensors, multi-electrode salinity sensors, and have formed a series of products. Based on optical sensors, Hash, YSI and WTW have developed a number of high-precision online water quality detectors, which provide a lot of data for hydrological observation and early warning in the monitoring area. In recent years, the research of ocean observation, monitoring and detection equipment has developed rapidly in China, and a considerable number of research results have been formed : Liu Jiwen [2] designed a high precision tunable digital light source, optimized the light source, and realized the wavelength tuning of the laser output with a precision of 0.91 pm. Based on the principle of fluorescence detection in optical method, Li Xinmin [3] designed a single light source water quality intelligent sensor, which can realize on-line accurate detection of water quality parameters. Li [4] studied the high-precision optical field time grating sensor that reduces the manufacturing difficulty of optical sensors. By comparing with the actual LED light intensity distribution curve, the method of analyzing the light field distribution characteristics by using the light source simulation model was further optimized.

However, so far most of the results have not formed products, and few have formed industrial chains. The sensors used in many established marine observation, monitoring and detection equipment are almost all foreign products. Among them, the factors restricting the industrial chain are mainly the low production accuracy of the core components of optical sensors, the high production price and the low conversion rate of scientific research. According to the current situation, the production process and overall design of the light source, grating and other core components of the optical sensor are optimized, which can improve the accuracy and service life of the optical sensor used in ocean monitoring.

2. Optimal design of the core components of optical sensors

2.1 Process optimization design of UV LED

There are many kinds of UV light sources used in optical sensors, including high pressure mercury lamp, microwave electrodeless UV light source and UV LED light source. High pressure mercury lamp power consumption, uneven irradiation, poor adjustability, low curing efficiency, heavy metal pollution, also need high pressure drive and cooling equipment. Microwave electrodeless UV light source is expensive [5], and the same lamp tube structure as mercury lamp limits its application. As a new light source of optical sensor, UV LED has developed rapidly. Compared with high-pressure mercury lamp and microwave electrodeless UV source, it has the following advantages: small size. Hard and durable, not easy to damage. Less energy consumption, high efficiency. Environmental protection is pollution-free. Low operating voltage, only about 3-5V. Power is easier to adjust [6]. Heat dissipation system requirements are low. The optical system is simple. However, the LEDs in the current market have problems such as unstable performance, fast attenuation, small radiation power and uneven radiation area [7], so the UV LED production process is optimized.

Aiming at the shortcomings of low radiation power and low uniformity of ultraviolet LED light source, the following processing procedures are designed : LED chip is directly solidified on the silver heat conduction block of low temperature co-fired ceramic substrate (LTCC) when solidifying, gold wire bonding the positive and negative electrodes of UV-LED chip to the corresponding electrode area of the ceramic substrate, the ceramic substrate is welded on the copper heat sink by tin ball, the thermal conductive silicone is connected with the copper radiator with fan.

2.2 Optimization design of UV LED light source packaging process

The packaging process of UV-LED has a great influence on the radiation power and uniformity of UV-LED light source. If bubbles appear in the dispensing and solidification processes, the light will be refracted at the bubbles, which affects the accuracy of the optical path. However, this problem is often difficult to avoid in the production process. The tightness and position accuracy of the welding

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line and the substrate are also difficult to control. The above difficulties can be reduced by process optimization design. The process was carried out in strict accordance with dispensing, solidification, welding line and packaging. Packaged products will need to be tested. The research and development of UV LED is aimed at the production process and packaging technology. The advantages and disadvantages of existing technologies are analyzed through preliminary research. The overall design scheme of the system is completed according to the requirements of the project parameters. After the preliminary scheme is completed, the sample production and testing are carried out. The technical parameters such as optical properties, thermal properties, stability and durability, packaging and testing are tested, and the production process and packaging technology are further improved by comparing with the performance required by the project. The specific flow chart is as follows:

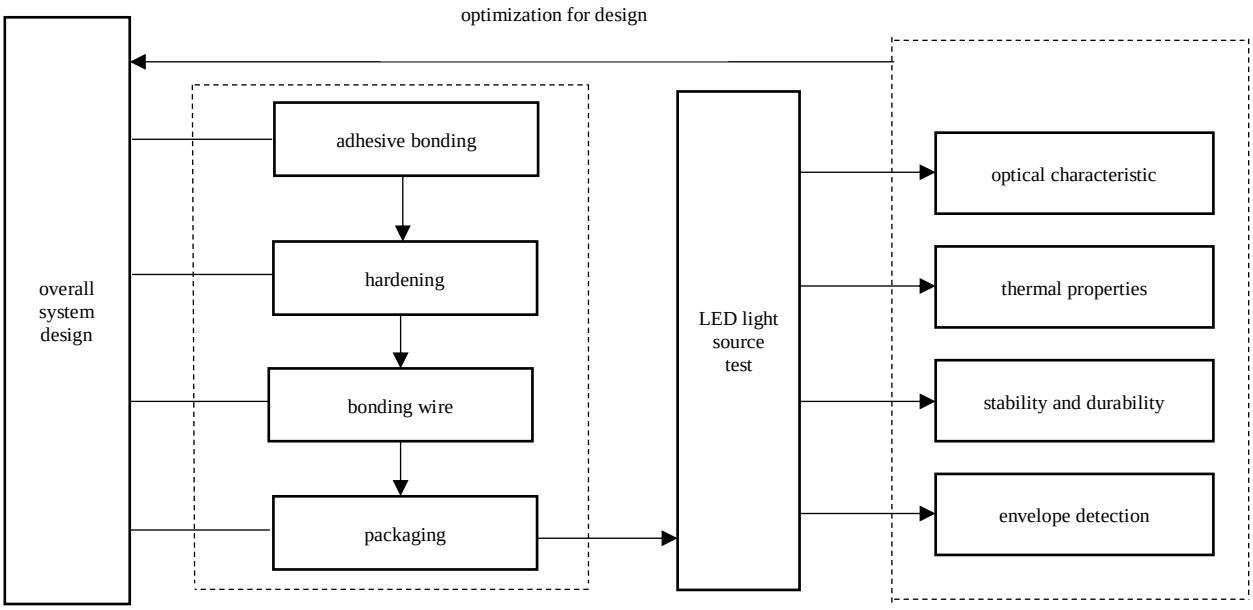

Fig. 1 Package process optimization design

3. Optimal design of grating fabrication

Grating is also the core component of the optical sensor, which determines the accuracy and imaging quality of the sensor. Gratings can be classified according to the different manufacturing materials, and different materials will also make the grating show different effects. At present, the common grating manufacturing materials are mainly PET, PP and PVC [8]. PET grating has stable chemical properties, acid and alkali resistance, but high chemical resistance, so it is difficult to bond. PP grating has hard texture and stable performance, which can be used for direct printing of UV ink, but the imaging effect is general. PVC grating is easy to bond, but it has some toxicity. PCF grating is a new type of grating fabrication material. In order to make it different from ordinary transparent materials, it can be realized by adjusting the internal pore structure and duty cycle. This is widely used in the production of high energy transmission, ultra-low loss, low nonlinear communication and other occasions. The grating of PCF material has low loss and good imaging effect, which can greatly improve the accuracy of the optical sensor [9]. In the process, the grating spacing, light source, exposure time and other parameters corresponding to the required grating wavelength are determined by the calculation of grating formation mechanism, strain effect model, and grating coupling equation. The influence of exposure time, grating position and grating length, fiber deformation, and PCF structure on the grating spectral characteristics is analyzed. Then, the control system parameters (grating position grating length, fiber deformation, and laser exposure) -grating writing-performance determined, as shown in Figure 2.

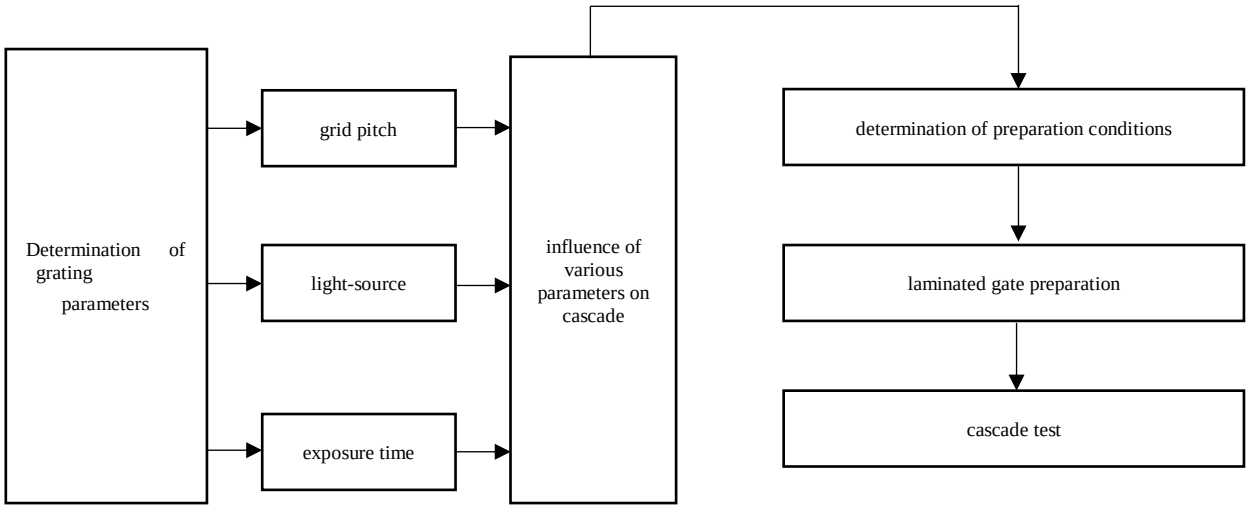

Fig. 2 Optimal design of grating fabrication

4. Conclusion

With the progress of technology, marine monitoring is becoming more and more important for improving marine economy and preventing marine environmental pollution. The core of marine monitoring is sensors. As a sensor with high precision and complete monitoring types, marine optical sensors are also the focus of the world. High precision and high stability optical sensors can greatly improve the ability of ocean monitoring. Through the optimization design of the production process and packaging of UV-LED light source and the selection of PCF materials to make grating can improve the accuracy of optical sensors and achieve the purpose of improving the level of sensor production.

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References

[1] He Chenyang, Korposh Serhiy,Correia Ricardo,Liu Liangliang,Hayes-Gill Barrie R.,Morgan Stephen P. Optical fibre sensor for simultaneous temperature and relative humidity measurement: Towards absolute humidity evaluation [J]. Sensors and Actuators: B.Chemical, 2021,344.

[2] Liu Jiwen.Digital light source design for fiber Bragg grating sensing [D].Harbin University of Technology, 2013.

[3] Li Xinmin. Design and performance study of single-source water quality intelligent sensor [D]. North University of Technology, 2020.

[4] Li. Single-field time grating sensor light source simulation and light field distribution analysis [D]. Chongqing University of Technology, 2020.

[5] Hou Shida, Zhou Shilu, Zhang Shuming, Li Hongguang.Solid light emitting materials based on carbon dots: synthesis and application in white light emitting diodes and optical sensors [J].New carbon materials, 2021,36 (03) : 527-545.

[6] Cazzulani Gabriele,Cinquemani Simone,Benedetti Lorenzo,Belloli Marco. Load estimation and vibration monitoring of scale model wind turbine blades through optical fiber sensors [J]. Engineering Research Express, 2021, 3(2).

[7] Fazzi Luigi,Valvano Stefano,Alaimo Andrea,Groves Roger M.. A simultaneous dual-parameter optical fibre single sensor embedded in a glass fibre/epoxy composite [J]. Composite Structures, 2021,270.

[8] Li Jingyao. Research on marine optical sensors based on SiO_2 waveguide [D]. Shandong University, 2020.

[9] Zhao Zhibin. Study on the characteristics of UV light emitting diodes for sensor chips [D]. Changchun University of Technology, 2013.