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Design and Implementation of a Flexible Raindrop Sensor

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Abstract: At present, raindrop sensors are widely used in automotive automatic wiper systems, intelligent lighting systems and intelligent sunroof systems. Ability to detect rainwater in real-time and quickly start up other equipment. Different raindrop sensors have different characteristics and applications. Those who work outside are susceptible to environmental pollution and damage. Flexible electronic products can be freely bent, wound and folded, which perfectly adapts to various space layout needs. These products not only exhibit more flexible bending characteristics, but also have excellent shape adaptability and ductility. It can well deal with the problems of easy damage to the external raindrop sensor and space layout. In this project, the method of rapid production of circuits on the surface of polyimide by laser ablation method is used to draw the circuit diagram of the raindrop sensor, then the flexible material is soaked to make it ion exchanged, and then the laser engraving machine is used for laser ablation to form a circuit, and finally a flexible raindrop sensor is prepared. The results show that the prepared flexible raindrop sensor has the functions and characteristics of traditional raindrop sensor, and also has a certain degree of flexibility.

Keywords: Raindrop sensor; Flexible electronics; Laser ablation.

1. Introduction

With the development of technologies such as 5G, the idea of the Internet of Things is gradually being realized. The Internet of Things refers to the integration of people, processes, data, and things, making network connections more relevant and valuable. Therefore, a large amount of data is the foundation for achieving interconnection, and sensors endow objects with "sensory" functions. For example, humans rely on vision, hearing, smell, and touch to perceive the surrounding environment, and objects can also perceive the surrounding environment through various sensors, which are more accurate and have a wider range of perception than human perception. For example, humans cannot accurately perceive the specific temperature value of an object through touch, nor can they perceive temperatures of thousands of degrees, nor can they distinguish subtle temperature changes, but sensors can. The collected data is transmitted to terminal devices through sensors, and then the massive data information is transmitted to the IoT system by the terminal devices. The IoT system performs a large amount of calculations based on this information to serve people. Along with the development of future technology, sensors will play a huge role. The raindrop sensor is an electronic sensor that detects rainwater or humidity. It senses changes in humidity in the environment, determines whether raindrops have fallen or the surface has become wet, and converts these changes into electrical signals for output. Raindrop sensors are widely used in fields such as weather monitoring, intelligent irrigation, and rainwater collection. It is usually composed of conductive materials and circuits. When raindrops fall on the surface of the sensor, the conductive material will undergo a change in resistance due to moisture, thereby altering the current or voltage in the circuit. By measuring this resistance change, it can be determined whether raindrops are falling[1-10]. Raindrop sensors typically have high sensitivity and fast response characteristics. They can detect the falling of rainwater in real time and provide reliable raindrop signal output. The working principle and signal output method of raindrop sensors may vary depending on different designs, but their basic principle is to detect raindrops by sensing changes in humidity. In summary, raindrop sensors are important electronic sensors used to detect the landing of raindrops and changes in humidity [5-6]. They are classified according to different working principles and application requirements, and play an important role in fields such as weather monitoring, intelligent irrigation, rainwater collection, vehicle safety, and smart homes. With the continuous advancement of technology, raindrop sensors will continue to develop and innovate, providing more efficient and reliable solutions for various application scenarios[11-16].

With the continuous improvement of people's health and other needs, as well as the continuous advancement of electronic technology, flexible electronic technology has emerged, which is expected to trigger a new intelligent revolution. As early as 2000, the American journal Science ranked flexible electronics technology as one of the top ten technological achievements in the world, along with human genome sketches and biological cloning technology. In recent years, due to its increasingly widespread and prominent applications in fields such as information technology, wearable devices, implantable devices, and intelligent robots, it has become a new technological frontier that scientists and multinational corporations from many countries around the world are vying to occupy.

Modern raindrop sensors typically use capacitive, piezoelectric, or optical principles to detect the presence and intensity of raindrops. Traditional raindrop sensors mostly work outdoors, and because they are made of metal circuits such as traditional photolithography circuit boards and electroless deposition circuit boards, they are exposed to the outside environment for a long time and are easily contaminated and damaged by the external environment, leading to problems such as metal rusting and damage to the raindrop sensor. With the advancement of materials science, the application of new sensor materials will make raindrop sensors more sensitive and durable, and flexible materials are one of the sensor materials. With the development of technology, the sensitivity and reliability of raindrop sensors continue to improve, while their volume is gradually decreasing, making them easier to install and integrate. In the automotive industry, raindrop sensors are often combined with automatic wiper systems to automatically adjust the speed of the wipers based on the amount of rainfall. In the future, raindrop sensors will continue to develop towards high precision, low power consumption, and intelligence. Meanwhile, with the development of IoT technology, raindrop sensors will be able to connect with other smart devices through wireless networks, enabling remote monitoring and data sharing. In addition, with the application of artificial intelligence technology, raindrop sensors will be able to perform more complex environmental perception, such as identifying different types of precipitation (rain, snow, hail, etc.), providing users with more accurate information.

Compared to traditional electronic components, flexible electronic devices have the characteristics of being lightweight, thin, soft, and bendable, with high flexibility, stretchability, and bendability. Therefore, new difficulties and challenges have been put forward for its components, especially for the materials and processes used in the production of electronic components. In recent years, there has been some progress in the materials and processes used in the production of electronic components. In terms of materials, people have started doping metal oxide films, such as indium tin oxide films, into flexible materials. Due to their excellent optical transparency and conductivity, they are widely used in the production of flexible electronic components. In terms of manufacturing process, one-dimensional linear structures are usually produced using wet spinning and electrospinning. Two dimensional planar structures can be prepared through coating techniques, deposition techniques, and printing techniques, among which coating techniques include spin coating, spray coating, dip coating, etc; Sedimentary techniques include chemical vapor deposition, physical vapor deposition, vacuum filtration deposition, electrolytic deposition, electrophoretic deposition, etc; Printing technology includes screen printing and direct pencil writing. Three dimensional structures are usually prepared using micro nano processing and printing techniques, among which micro nano processing includes photolithography technology, laser processing, anodized aluminum template method, wrinkling method, self-assembly technology, etc; Printing technologies include 3D printing technology, 4D printing technology, direct laser writing, roll to roll technology, etc.

So far, many characteristic processing technologies have been developed based on the new generation of laser direct writing, such as designing nanobelt arrays, one-step method for preparing nanotunnels, ultra smooth nanogrooves, nanoelectrodes, nanograyscale masks, MEMS structures, surface hydrophilic and hydrophobic structures, patterned quantum dots, widely controllable folded structures, and nanolens arrays, etc., demonstrating the application prospects of the new generation of laser direct writing. A large number of experimental studies have proven the reliability of the new generation of laser direct writing system, and also proved that this system can utilize diverse processing reaction mechanisms, such as oxidation, cutting, solidification, melting, photochemical reactions, guided self-assembly, etc. This article successfully prepared a raindrop circuit using laser thermal etching method and conducted simple tests on the circuit.

2. Experimental Procedure

Use the drawing software KLEKI for drawing. The thickness of the line is 30 and the color of the line is black, as shown in Figure 1. Note that when drawing a raindrop sensor, it should be noted that the raindrop sensor itself cannot form a complete circuit.

Figure 1. Circuit Template for Laser Thermal Etching

Prepare potassium hydroxide and silver nitrate solution, and check the laser engraving machine, etc. Cut the soaked polyimide film into multiple 50mm * 50mm sizes using scissors and a ruler, and then place them in a cleaning instrument to remove stains and ensure the cleanliness of the film. Place the cleaned film in a prepared potassium hydroxide solution (concentration of 5%) and soak for one hour. Use tweezers to remove the soaked film, then clean the film multiple times with purified water to remove other stains on the surface, and then soak it in a 0.1mol/L silver nitrate solution for 24 hours. After soaking for 24 hours, use tweezers to remove the film and rinse it multiple times with clean water to ensure that the polyimide film is free of stains. Place the polyimide film with surface bound silver ions flat on the base of the laser engraving machine, fix the four corners of the polyimide film with adhesive tape, connect the Bluetooth of the laser engraving machine, input the pre drawn circuit diagram and start printing engraving. The printed sample is shown in Figure 2.

Figure 2. Physical picture of raindrop sensor

3. Testing of Flexible Raindrop Sensor

Firstly, check if the circuit connection is correct and if the sensor surface is dry. If it is wet, it does not meet the testing requirements. Next, use a spray bottle to spray water drops, simulate raindrops, observe the reaction of the raindrop sensor, and observe whether the small lights in the circuit can light up normally (Figure 3). By connecting raindrop sensors with different electrode distances and intervals, and comparing them with traditional raindrop sensors, observe whether changes in these elements will also affect the sensitivity of the raindrop sensor, in order to verify whether flexible raindrop sensors have the same functions and characteristics as traditional raindrop sensors. After completing the conductivity test of the flexible raindrop sensor and comparing it with traditional raindrop sensors, the curved flexible raindrop sensor still lights up normally when the small light is on (Figure 4), and the surface flexible raindrop sensor can still work normally when bent. After testing, the flexible raindrop sensor produced in this project has the same functions and characteristics as traditional raindrop sensors, and can also be bent, with a certain degree of flexibility.

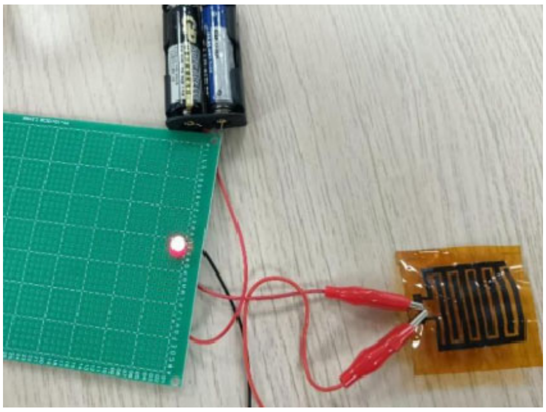

Figure 3. Diagram of Normal Conductivity

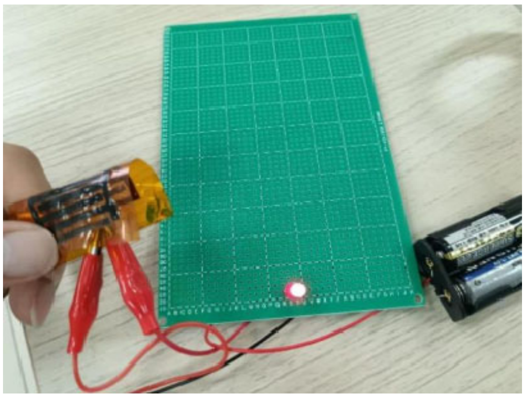

Figure 4. Conductivity diagram in bent state

4. Conclusion

This article mainly introduces the design and implementation of a flexible raindrop sensor. Through the drawing of a resistive raindrop sensor, familiarity and use of polyimide film immersion treatment and laser engraving machine, a flexible raindrop sensor has been successfully fabricated. Connect the made flexible raindrop sensor to a circuit for testing. Experimental results have shown that flexible raindrop sensors not only have the same functions as traditional raindrop sensors, but also can operate normally when the raindrop sensor is bent. Flexible materials, as a new type of sensor material, have great potential for development. Although there are problems such as material curling during laser engraving at present, with the development and progress of technology, some problems will be solved. Combining flexible materials with sensors to endow them with more functions. In future development, only designs with more advantages and functions can stand out. Vigorously promoting the design and research and development of multifunctional products will bring more convenient and efficient services to people.

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