Research on the Process of Rapid Preparation of Flexible Circuits by Laser Sintering

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Abstract

Due to its unique characteristics and distinguishing features from other circuits, the flexible circuit market has rapidly expanded. This project utilizes specific experimental methods and processes, taking advantage of the characteristics of potassium hydroxide and silver nitrate, as well as laser sintering technology to achieve rapid preparation of flexible circuits. The study investigated the effects of various process parameters on the preparation process and flexible circuit performance. Through experimental data and result analysis, the feasibility and advantages of this process have been revealed, providing a novel and efficient preparation process for the field of flexible electronics, and having important theoretical significance and practical application value.

Keywords

Flexible circuit, Laser sintering, Rapid preparation.

1. Introduction

With the rapid development of modern electronic technology, flexible electronic devices have shown great potential for applications in many fields, such as wearable devices, flexible displays, biomedical sensors, etc. In these applications, the research on the preparation process of flexible circuits as a key component for connecting electronic components is of great significance. The traditional methods for preparing flexible circuits have some limitations, such as complex processes, high costs, and difficulty in achieving large-area preparation. Therefore, developing a simple, efficient, low-cost and suitable flexible circuit preparation process for large-scale production has become a current research hotspot.Flexible electronics is an emerging electronic technology that involves the fabrication of organic or inorganic electronic devices on flexible or stretchable substrates. It has unique flexibility, stretchability, and efficient, low-cost manufacturing processes. Among the various new electronic products we are looking forward to, the characteristics and advantages of flexible electronic products are particularly prominent. They generally have features such as flexibility, printability, mimicry, aggregation, and elasticity, making them suitable for fields such as national defense, healthcare, energy, and information.Flexible circuits have a wide range of application prospects and advantages compared to hard circuits. Physical characteristics: Flexible circuits allow for greater bending and deformation capabilities, while traditional hard circuits are usually composed of fixed shaped conductive lines that are less able to withstand large pressures or distortions. Material selection: Flexible circuits typically use flexible substrates such as polymers, plastic films, etc., while hard circuits tend to use fiberglass boards or metals as substrates. Design flexibility: Flexible circuits can be designed into various complex two-dimensional or three-dimensional structures, suitable for complex surface installations, while hard circuits are often limited to planar design. Production process: The manufacturing of flexible circuits usually uses printing, inkjet or other non cutting processes, allowing for large-scale low-cost production, while hard circuits often require precise etching or photolithography steps. Application areas: Flexible

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circuits are widely used in applications that require lightweight, bendable, or wearable features, such as foldable phones, medical devices, and electronic tags, while hard circuits are more suitable for fixed position applications that require high strength and durability.

Technological development is moving from traditional rigid design to the future of flexible external dimensions. The advancement of flexible technology will provide new functionalities that were previously unattainable in rigid designs, particularly in markets such as healthcare, wearable devices and the Internet of Things, sensors and smart textiles. Flexible technology is paving the way for the future world, providing power, structures, and processes that enable our bodies and lives to be continuously monitored and improved. Flexible electronics typically use ultra-thin and highly elastic organic polymers as substrates, with various functional modules embedded inside through layer by layer stacking. To achieve stretchability, metal compounds are generated through relevant reactions.

The materials and structures selected for flexible circuit products have a crucial impact on their electromechanical, biological, and other properties. In order to better meet the performance requirements of practical applications, suitable materials, structures, and processing techniques should be selected in the design process to better serve human sports health monitoring. Metal based, carbon based, semiconductor, polymer and composite materials, etc., due to their unique properties. Polyimide (PI) has outstanding thermal stability, excellent radiation resistance, and dielectric properties, and is widely used in various aerospace vehicles such as satellites. It is one of the important thermal control materials for spacecraft. As an emerging material processing method, optical sintering technology has the advantages of high precision, high speed, and non-contact processing, providing new ideas for the preparation of flexible circuits. It is expected to overcome the shortcomings of traditional preparation methods and provide strong support for the development of flexible electronic devices. [1-11].

2. Experimental equipment

Laser engraving machine is a device that uses a high-power density laser beam to generate a chemical reaction on the workpiece, leaving permanent marks. The laser engraving machine generates laser light through a laser, which is transmitted through a reflection mirror and directed onto the processing material through a focusing mirror. Non contact processing: Laser processing does not require the use of cutting tools, avoiding issues such as tool wear and disassembly, while also reducing mechanical stress on materials, resulting in minimal thermal deformation during the processing; High processing flexibility: The laser beam is easy to focus, diverge, and guide, and can easily obtain different spot sizes and power sizes to meet different processing requirements. Capable of carving and cutting complex shapes on various materials, and achieving precise processing effects; Wide range of processing materials: suitable for processing various metal and non-metal materials... especially suitable for processing high melting point, high hardness, and high brittleness materials. The application fields of laser engraving machines are very wide. During the processing, pay attention to observing the operating status of the equipment, such as whether the laser power, engraving speed, cooling system, etc. are normal. Avoid touching equipment or materials during the processing to prevent danger. To use a laser engraving machine, it is necessary to carefully read the equipment manual, master the correct operating methods and precautions, to ensure the normal operation and processing quality of the equipment. At the same time, safety should be taken into account to avoid danger during use. The relevant solution configuration first prepares materials and equipment, then calculates the required mass of potassium hydroxide and silver nitrate, zeros the electronic balance, places a clean weighing paper on the balance, and carefully places the solid with calculated mass on the weighing paper for weighing. Slowly add the weighed solid into the beaker while stirring continuously with a glass rod to accelerate

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dissolution. The prepared solution should be properly stored and placed in a suitable environment, with attention to safety to prevent the solution from splashing onto the skin or eyes.

3. Experimental operation process

The first step is to prepare the materials and equipment. Step two, use scissors and a ruler to cut the polyimide film into the appropriate size, and then place it in a cleaning instrument to remove stains and ensure the cleanliness of the film. Place the cleaned film in a prepared potassium hydroxide solution (mass fraction 10%) - treat the polyimide film with KOH, open the imide ring through alkali treatment, and form amide structure, carboxylate salt, and potassium imide acid, as shown in Figure 4-1-1. Later, the length of immersion in potassium hydroxide solution will be used to determine whether the performance of flexible circuits can be improved by changing the soaking time of polyimide films. Step three, after soaking for a period of time, wear gloves to remove the soaked film and rinse it clean with pure water. Then place it in a 0.2mol/L silver nitrate solution for one day to allow the potassium ions in the potassium imides generated on the surface of the polyimide film to exchange with the silver ions in the silver nitrate solution to form a silver ion activated membrane. After removal, clean it with deionized water and use the silver nitrate solution for ion exchange to prepare a polyimide film with surface bound silver ions. Step four, place the polyimide film with surface bound silver ions flat on the base of the laser engraving machine, input the pre drawn circuit diagram, and start printing engraving. Silver ions precipitate during the high-temperature heating of the laser, forming conductive lines. Step five, assemble materials such as batteries and circuits into a circuit board to test whether the flexible circuit, mainly composed of polyimide film with surface bound silver ions, can complete basic functions such as power on.

To investigate the effect of soaking time in a fixed concentration solution on the experiment, as a unified variable, the effect of soaking time in a fixed concentration silver nitrate solution for 24 hours on the soaking time of potassium hydroxide solution was explored. The conductivity of polyimide film is closely related to the soaking time of potassium hydroxide. The longer the soaking time, the more hydroxide ions will adhere to the polyimide film. Similarly, there will be more ion exchange with silver ions in the silver nitrate solution, resulting in more metal precipitation through laser sintering and stronger electrical performance. Study the effect of soaking time in a fixed concentration solution on the experiment. As a unified variable, investigate the effect of soaking time in a fixed concentration potassium hydroxide solution for 2 hours on the soaking time of silver nitrate solution. When ensuring consistent soaking time of potassium hydroxide solution, the soaking time of silver nitrate solution is not the main influencing factor. When the number of hydroxide ions attached to the film is constant, the number of nitrate ions is affected by the number of hydroxide ions. The length of time only ensures more thorough exchange, so the length of time is not the main influencing factor. It will not increase the conductivity over time as the soaking time of nitric acid solution reaches 24 hours to ensure electrical continuity, and as the soaking time increases, it will not improve the conductivity. In this experiment, polyimide films soaked in potassium hydroxide solution for 2 hours and silver nitrate solution for 24 hours were carefully selected. After soaking, carefully remove these films and immediately rinse them with plenty of water to thoroughly remove any residual solution on the surface of the films. Next, gently wipe the surface of the film with a soft and clean cloth, ensuring that it is clean and free of any residual liquid. The processed film is placed steadily on a laser engraving machine, and through the high-temperature process of laser sintering, the substances in the film react to precipitate conductive metals. This process requires precise control of the intensity, frequency, and duration of the laser to ensure uniform precipitation of conductive metals and good conductivity. Design welding circuits and use circuit boards, batteries, wires, etc. to form subsequent verification thin film electrification experiments. When the sintering step is successfully completed, the carefully crafted film is placed in a self-made circuit for detecting the power status (the specific circuit structure is shown in Figure 1). Use crocodile clip wires to firmly clamp the deposited lines on the film, and then connect the power supply for testing. If the LED lights in the circuit can light up, it undoubtedly proves that the film has good electrical performance; On the contrary, if the LED light is not on, it indicates that the film has not been successfully powered on. Slowly bend the film while keeping the circuit wiring energized, and observe the status of the LED light. Once the LED light remains lit even when the film is bent, it fully demonstrates the excellent "flexibility" of the film. This series of rigorous experimental procedures and meticulous observation steps aims to comprehensively and accurately evaluate the performance of the prepared polyimide film in terms of conductivity and flexibility, providing a solid and reliable basis for subsequent applications and optimization.

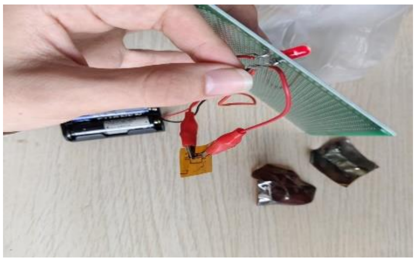

Figure 1 Detection diagram

4. Conclusion

This article is about the application research of laser sintering technology in the rapid preparation of flexible circuits, aiming to improve the electrical performance, mechanical performance, and stability of flexible circuits through specific experimental procedures and parameter optimization. The demand for flexible circuits in the market is growing, and traditional preparation methods have limitations. This study is of great significance. Introduced the differences and application fields between flexible circuits and hard circuits, and elaborated on the technological development trends. Flexible circuits are prepared using polyimide as the flexible material, laser engraving machine and laser sintering technology as the basis, combined with chemical reactions of potassium hydroxide and silver nitrate. Analyzed and solved problems from the aspects of materials, structure, manufacturing process, cost, and complexity, and summarized and compared their preparation and modification methods. Discussed the current problems and future development directions.

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