Design of an Arduino Nano-based Digital Spin Coater for Polystyrene Coating on Biosensors
A Methodological Approach

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ABSTRACT
The design of an Arduino Nano-based spin coater for coating biosensors using polystyrene has a very important urgency in the biomedical field. This is because biosensor coating is an important stage in making a biosensor which affects the quality and detection performance. By using an Arduino Nano-based spin coater design, coating can be done more quickly, efficiently and evenly. In addition, the use of components that are more affordable and easy to obtain on the market can reduce production costs, this is an important factor in the biosensor industry. The accuracy and sensitivity of biosensor detection can also be increased through uniform coating, so that it can be used for various applications, especially in the health sector. The purpose of this research is to design an Arduino Nano-based spin coater instrumentation system accompanied by a spin coater chamber and substrate design for various applications in the biomedical field. The method used is conducting a preliminary study, conducting a needs analysis, designing a spin coater instrumentation system, and designing a spin coater chamber and substrate. This research has resulted in the design of an Arduino Nano-based spin coater instrumentation system accompanied by a spin coater chamber and substrate design that are ready to be produced and tested for the function and performance of the tool.

Keywords: *digital spin coater, polystyrene coating, biosensors*

1. INTRODUCTION

Modification of the biosensor surface with a thin layer of polystyrene can increase the sensitivity and selectivity of the biosensor [1]. Biosensors are an important technology in the biomedical field [2] which can be used for the detection and analysis of various types of biological compounds and molecules. One of the important stages in making a biosensor is coating [3, 4, 5], where a thin layer of material that functions as a detection element is coated on the surface of the substrate. To carry out coating evenly [6, 7, 8, 9] and efficiently, a special tool is needed called a spin coater. Even though spin coaters have been widely used in the biosensor industry, these tools are still relatively expensive [10, 11] and less flexible in terms of parameter settings. Therefore, it is necessary to conduct research on the design of an Arduino Nano-based spin coater that is more efficient, cheaper and flexible in setting parameters for coating biosensors using polystyrene. With this research, it is hoped that it can increase the efficiency and accuracy of biosensor coating, as well as have a positive impact on the development of more sophisticated and innovative biosensor technology in the future.

So far, a lot of research has been carried out regarding spin coater design, one of which is the development of a microcontroller-based spin coater design. Several studies have produced spin coater designs that can optimize the coating process with high accuracy, such as a microcontroller-based spin coater [12], an Arduino Uno-based spin coater [13, 14], and an Arduino Nano-based spin coater [12]. However, not many studies have used Arduino Nano as a basis for developing spin coater designs. Therefore, research on the design of an Arduino Nano-based spin coater for coating biosensors using polystyrene is very important to carry out. By using this technology, it is hoped that it can significantly increase the speed and accuracy of the biosensor coating process and enable mass production of biosensors at a cheaper and more efficient cost.

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The problem-solving approach in research on Arduino Nano-based digital spin coater design can be done in several steps. First, it is necessary to carry out a literature study to understand the design, performance, and deficiencies of the existing spin coaters. Second, the designer can determine the research objectives and hypotheses that will be tested in the research, such as optimizing energy use in the spin coating process. Third, designers can design and build a digital spin coater prototype based on Arduino Nano, which includes selecting appropriate components, control system design, and manufacturing processes. Fourth, the designer can conduct experiments to validate the hypotheses that have been formulated previously. In this stage, it is necessary to analyze the data to see whether the experimental results are in accordance with the hypotheses that have been formulated. Finally, designers can develop and improve the spin coater design based on the results of experiments and evaluations that have been carried out previously. In this stage, it is necessary to iterate on the design and control parameter settings so that the spin coater can perform better and be more efficient. With a structured and systematic problem solving approach, research on the design of a digital spin coater based on Arduino Nano can produce a spin coater that is more accurate, efficient, and can be used for various applications in industry and laboratories.

The state of the art of the Arduino Nano based digital spin coater design is the adoption of microcontroller technology to control the rotation speed and spin time on the spin coater. This technology allows the spin coater to operate at a consistent and precise speed, thereby producing high quality thin films. The novelty of the Arduino Nano-based digital spin coater design lies in the use of an open-source platform that allows designers to freely modify and develop the source code. In addition, the Arduino Nano-based digital spin coater design is smaller and lighter than conventional spin coaters, making it easier to move and use in various laboratory environments. In addition, the Arduino Nano-based digital spin coater design can also be integrated with temperature sensors and speed sensors, so that it can monitor environmental conditions and set control parameters more accurately. This can improve the efficiency and accuracy of the spin coater, as well as reduce the time and cost involved in making thin films. Overall, the Arduino Nano-based digital spin coater design is an innovative technology and has the potential to improve performance and efficiency in thin film manufacturing, and can be used in various applications in the fields of materials science, semiconductor and information technology.

2. METHODS

The method used in this research is conducting a preliminary study, conducting a needs analysis, designing a spin coater instrumentation system, and designing a spin coater chamber and substrate as shown in Figure 1.

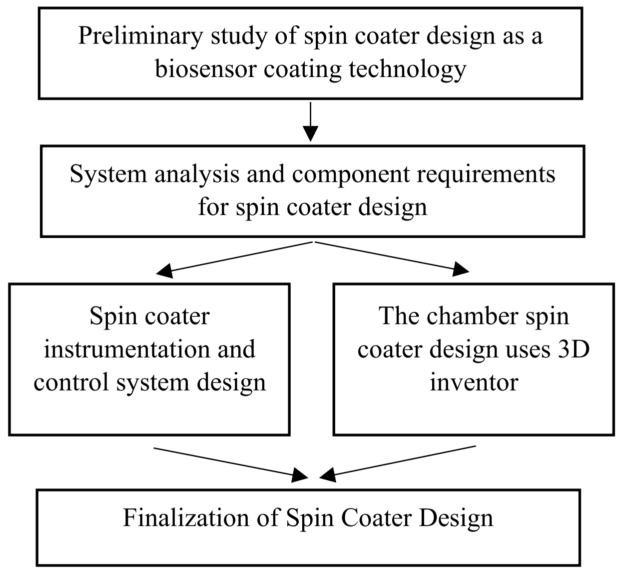

Figure 1 Block diagram of research stages

A preliminary study on spin coaters as a biosensor coating technology was carried out to understand the working principles, applications and advantages of spin coaters in biosensor coating as well as to analyze various coating technologies that can be used in biosensor development by considering the needs and objectives of this research. Analysis of component requirements for the spin coater design was carried out to identify and analyze the components needed in the spin coater design as well as determine the technical specifications for each component that will be used in the Arduino Nano-based spin coater design. Spin coater instrumentation system design is carried out to design a spin coater instrumentation system based on analysis of component requirements that have been carried out and integrating the components, applying appropriate program logic and control algorithms to regulate rotation speed, time and other parameters on the spin coater. Spin coater chamber and substrate design is carried out to design a chamber that is in accordance with the aim of optimizing spin coater performance, including design that considers coating needs and possible environmental controls, designing a spin coater substrate that supports consistent and effective coating.

3. RESULTS

The working principle of the spin coater uses the concept of circular motion. When a spin coater is used, centripetal and centrifugal forces will occur and heavy forces will occur which produce frictional forces between the substrate and the solution. This concept is used as the basis for designing a spin coater.

Components used to design the spin coater include 3s lipo battery, LM2576 regulator, 100 µH power inductor, 5822 3A diode, 100 µF Elco capacitor, 1000 µF Elco capacitor, 330 Ω resistor, 10 KΩ resistor, 3mm LED, push button, Arduino nano, 16x2 I2C LCD, LM393 IR speed sensor, 20A ESC, 2200 KV brushless motor, and 3d print box.

The design of the spin coater circuit is shown in Figure 2. The spin coater circuit is used to control the rotational speed of the motor and the rotation timer. This spin coater design can rotate stably at 8000 RPM for 60 seconds. The spin coater design uses Arduino Nano as the motor controller and the timer used. The RPM value can be adjusted as needed using the push button in 1000 RPM increments. The RPM value and timer will be displayed on the LCD screen. The spin coater circuit design will be printed onto the PCB and the components will be mounted on the PCB. The spin coater circuit after installing the components on the PCB is shown in Figure 3.

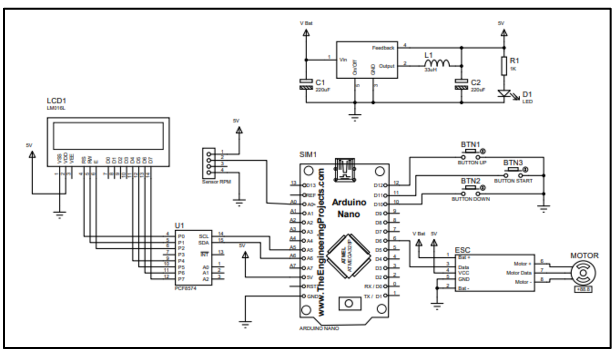

Figure 2 Spin coater circuit design

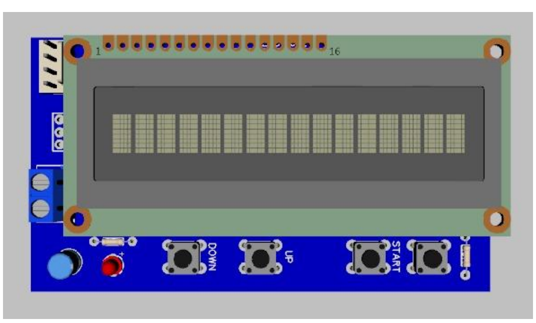

Figure 3 The spin coater circuit after installing the components on the PCB

The design of the spin coater series has been made, compiled and equipped with components, then the chamber design process is carried out using CAD software. The design concept of this chamber consists of the lower part as the motor and controller and the upper part of the chamber which consists of the substrate and the chamber cover. The chamber design is shown in Figure 4. The chamber has dimensions of 13 x 13 cm, with a diameter at the substrate laying area of 10 cm.

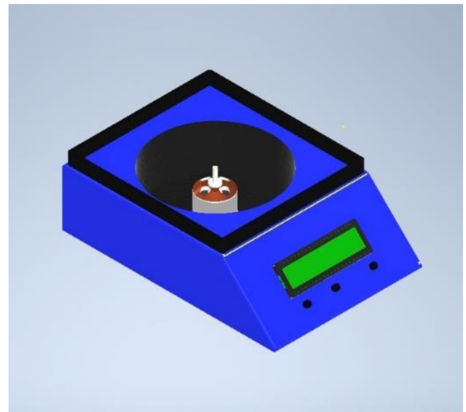

Figure 4 Chamber design

4. CONCLUSION

This research has resulted in the design of an Arduino Nano-based spin coater instrumentation system accompanied by a spin coater chamber and substrate design that are ready to be produced and tested for the function and performance of the tool.

AUTHORS' CONTRIBUTIONS

Dena Anugrah has contributed to writing articles, Mira Setiana has contributed to data analysis, Amalia Cemara Nur'aidha has contributed to making digital spin coater designs, Bangkit Ina Ferawati has contributed to paying for international seminars and publications, and Faza Agisna has contributed to collecting data

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REFERENCES

[1] Setiana M, Zafirah TN, Sakti SP. The response of QCM sensor coated with polystyrene in contact with potassium chloride solution. In: Materials Today: Proceedings. 2020.

[2] Haleem A, Javaid M, Singh RP, Suman R, Rab S. Biosensors applications in medical field: A brief review. Vol. 2, Sensors International. 2021.

[3] Theyagarajan K, Kim YJ. Recent Developments in the Design and Fabrication of Electrochemical Biosensors Using Functional Materials and

Molecules. Biosensors (Basel). 2023 Mar 27;13(4):424.

[4] Miranda B, Rea I, Dardano P, De Stefano L, Forestiere C. Recent advances in the fabrication and functionalization of flexible optical biosensors: Toward smart life-sciences applications. Biosensors (Basel). 2021;11(4).

[5] Kumar S, Sharma R, Bhawna, Gupta A, Singh P, Kalia S, et al. Prospects of Biosensors Based on Functionalized and Nanostructured Solitary Materials: Detection of Viral Infections and Other Risks. Vol. 7, ACS Omega. 2022.

[6] Soonmin H. Thin Films Deposited by Spin Coating Technique: Review. Pakistan Journal of Chemistry. 2021;11(1–4).

[7] Nguyen AN, Solard J, Nong HTT, Osman C Ben, Gomez A, Bockelée V, et al. Spin coating and micro-patterning optimization of composite thin films based on PVDF. Materials. 2020;13(6).

[8] Chen X, Hu Y, Xie Z, Wang H. Materials and Design of Photocatalytic Membranes. In: Current Trends and Future Developments on (Bio-) Membranes. Elsevier; 2018. p. 71–96.

[9] Buonomenna MG. Smart composite membranes for advanced wastewater treatments. In: Smart Composite Coatings and Membranes. Elsevier; 2016. p. 371–419.

[10] Rahman A, Novyanto O, Alfiyati N, Sidik A, Idris I, Nugraha AR. Design and Characterization of Spin Coater to Support National Semiconductor Industry. Jurnal Standardisasi. 2019;21(3).

[11] Yepuri V, Satyanarayana A, Garaga R. Economical construction of spin coater for the fabrication of dielectric reflectors. Mater Today Proc. 2023.

[12] Sadegh-Cheri M. Design, Fabrication, and Optical Characterization of a Low-Cost and Open-Source Spin Coater. J Chem Educ. 2019.

[13] Hameed AS, Madlool RA, Ridha NJ, Hussein BM, Mohamad Alosfur FK, Tahir KJ. Fabrication of Spin Coater Device using Hematocrit Centrifuge with Vacuum Substrate Holder for Thin Film Deposition. Materials Research. 2022;25.

[14] Irzaman, Syafutra H, Siskandar R, Aminullah, Alatas H. Modified Spin Coating Method for Coating and Fabricating Ferroelectric Thin Films as Sensors and Solar Cells. In: Thin Film Processes - Artifacts on Surface Phenomena and Technological Facets. 2017.