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Development of Low Cost and Efficient Automated Spin Coating System for Effective Deposition of Thin Films

Ulhas S.Sonawane[a]*, Anil G. Khairnar[b], Prerna A. Pandit[b]

[a] *Department of Electronics, S.T.E.S. & Co-Op. Edu. Soc. Ltd's, Science Senior College, Shahada*
[b]*Department of Electronics, K.R.T Arts,BH Commerce and AM Science (K.T.H.M.) College, Nashik*

A B S T R A C T

A spin coater system is widely used for the synthesis of thin films and nanostructures. In this paper we present a spin coater with inexpensive electronic and mechanical components. Spin time and speed of motor controls the thickness of film. Here efforts have been made to control the spin time using automation of spin coating unit. Microcontroller 89C52 has been successfully used to control the spin time and thickness of the films. Maximums peed of DC motor is specified to 2500 rpm to rotate the substrate. In conclusion, we have developed cost efficient automated spin coater having versatile features for the coating of thin films and nanostructures.

Keywords:Spin Coating, Sol Gel, Automation, Microcontroller

1. Introduction

Thin film technology and development nanostructures gives greater insight for development in basic and applied sciences. Thin film technology and nanotechnology mainly contributes in the miniaturization of electronic devices. Development of new smarter and smaller devices needed the new smarter materials with different structures along with smarter processing technology. There are different techniques like Atomic Layer Deposition (ALD) [1-3], spray pyrolysis [4-5], sol-gel process [6], sputtering [7] ,chemical vapor deposition [8] etc. are available for the synthesis and fabrication thin films and nanostructures.

Wet coating techniques are used for the fabrication of thin films [9]; using the developed spin coater the films are grown. For one side coating, a spin coating technique is used. In this case, the substrate usually silicon wafer or glass is placed on a spinner, which is rotated at about 2000 rpm while solution is dipped on the centre of substrate. In most cases, a film thickness is between 50 and 500 nm will result. Controlling the thickness is matter of controlling the solution viscosity and revolutions, a film thickness is achieved by controlling spinning rate.

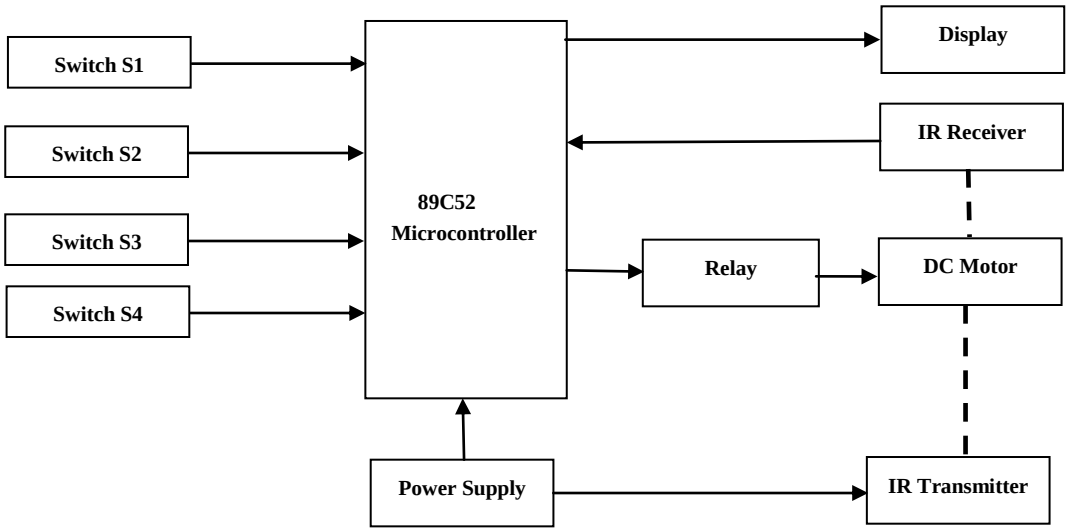
This work presents the automation of spin coating system for effective film deposition. The article is organized as follows in second section spin coating system mechanism is discussed in brief, followed by the block diagram of system and then the flowchart is given. Then in next section the deposition of thin film procedure using developed spin coating system is discussed and at last the conclusion.

2. Background of Spin Coating System:

In spin coating uniform thinfilms are applied to flat substrates. In a nutshell, an excess of the solvent is poured over the substrate, which is then spun at a high speed to disseminate the fluid using centrifugal force.A spin coater, or simply spinner, is a machine used for spin coating.Rotation is continued while the fluid spins off the edges of the substrate, until thedesired thickness of the film is achieved. The applied solvent is volatile,and evaporates. So, the higher the angular speed of spinning, thethinner the film. The film's thickness is also determined by the solution's concentration and the solvent used.

Spin coating is widely used in micro fabrication, where it can be used to create thin films with thicknesses below 10 nm. It is used intensively in photolithography, to deposit layers of photo resist about 1 micron thick.

3.Block Diagram of the system:



1) Switches: Available on front panel for controlling the different operations such as On/OFF, setting rpm and revolution time etc**.**

2) IR transmitter and receiver: In this project work there is pair of infrared transmitter and receiver for the purpose of counting of revolutions of the DC motor per minute. The arrangement of transmitter and receiver have been made in such a way that, the transmitter is below the circular sheet attached to motor and position of detector is exactly at the top of transmitter over the sheet. This arrangement will assist to count the exact rotations of motor by cutting the IR beam. The o/p of photodetector receiver is provided to microcontroller unit. When circular sheet blocks the IR beam, the logical state of IR photodetector changes from low to high.

3) Relay: Relay is used here for driving the DC motor depending upon the output provided by the microcontroller to relay driver circuit.

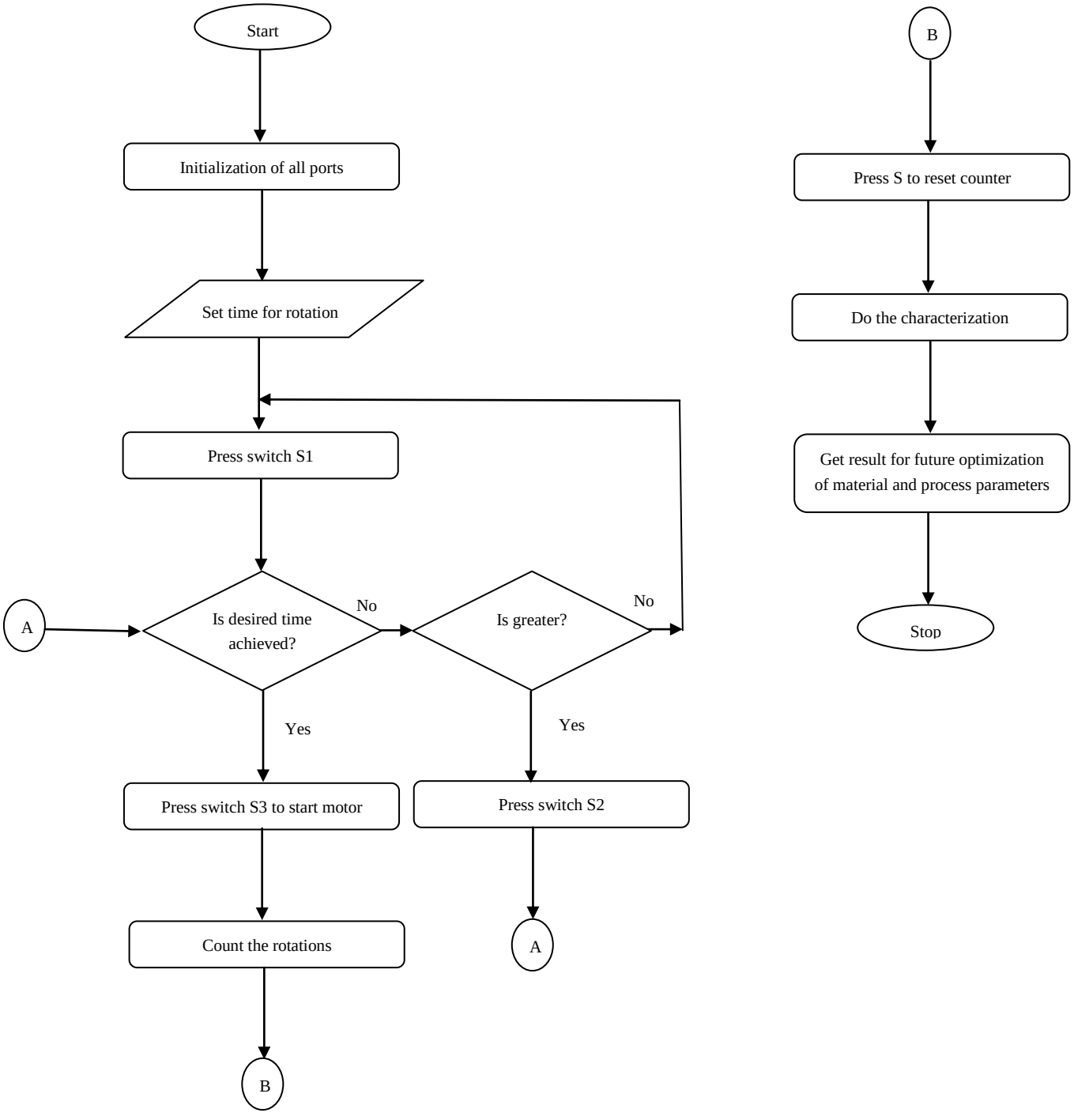
4) DC Motor: The motor operating on D.C. supply is used to spin the substrates operating on 6V D.C. DC motor used here has 2500 rpm. The speed and time of rotation can be set with the switches provided on front panel

5) Display: Display used here are common anode seven segment displays. These are for showing the time of rotation and also show the number of revolutions taken by the dc motor.

6) Microcontroller unit: Microcontroller is the heart of this project. IC 89C52is used in this project for the following advantages –

a. Internal 8k bytes of EPROM for feeding program so that there is no need of external EPROM.
b. Four 8 bit I/O ports P0, P1, P2, and P3.
c. Operating voltage of 3.5 to 6V DC. This can be easily available by using voltage regulator ICs.
d. Internal 128 byte RAM to store temporary storage of data.
e. Three bit Timer/Counter is present for timing and counting purpose.
f. Four external and two internal interrupts are available

4 .Flowchart of software developed:



5. Procedure of film deposition

1) **Cleaning of substrate:** The cleaning process of the substrate is done in clean room, in order to avoid theatmospheric contaminants. The substrate used in this work is microscopic glass.Initially, the substrate is to be deposited is dipped in the trichloroethylene for 5min. Secondly; the substrate is dipped for 5 min in acetone. Lastly thesubstrate is dipped into methanol for 5 min. then substrate is rinsed in de-ionisedwater and dried with air or hot air gun.
2) **Deposition of thin film:** Cleaned substrate is placed on the developed spin coater and solution is spread on the substrate by revolving the substrate. While deposition of film number of coatings and spin time can be varied for optimizing the results.
    a. **Coating Procedure:** This can be done by using a nozzle and pouring the coating solution or by spraying it onto the surface. A substantial excess of coating solution is usually applied compared to the amount that is required.
        - The substrate is accelerated up to its final, desired, rotation speed
        - The substrate is spinning at a constant rate and fluid viscous forcesdominate the fluid thinning behaviour.

    The substrate is spinning at a constant rate and solvent evaporation dominatesthe coating thinning behaviour. The coating thickness can be controlled basicallyby the controlling the spin time and concentration and viscosity of coating liquid.After the deposition the films are dried, from the time the solution is applied to thetime it gels, there is about ~50% weight loss. Yet the films remain adherentcontinuous and complete surface coverage. Drying is complete when there is nofurther weight loss. The drying temperature is about 250^0C.

Conclusion:

The microcontroller based Spin coater has been successively developed for the deposition thin films. The sample films were successively grown on microscopic glass substrate by controlling the spin time and speed of motor. Spin coater is having excellent control on the spinning of substrate which controls the uniformity of the samples. Thus we have developed most efficient, reliable, effective and versatile instrument for the good quality of controlled deposition of the thin films having no of potential applications in the different fields.

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