*Journal of Modern Science and Technology*
*Vol. 1. No. 1. May 2013 Issue. Pp.126-134*

# Cost-Effective Home-Made Spin Coater for Depositing Thin Films

Mohua Fardousi, M.F. Hossain, M.S. Islam and Sharik Rahat Ruslan

*A simple, low cost spin coater design has been described in this paper. This low cost coating system is used to deposit thin films. The system can be easily built with the knowledge of machine and electronics. It's constructed by using a dc motor and electronic circuit, designed to control the spinning speed. The spinning speed varies from 350 to 3800 RPM. In our design, the spinning speed is controlled manually by 11 steps.*

**Keywords:** Spin Coater, Thin Film, Zno, Spin Coating.

**Fields:** Materials Science and devices

## 1. Introduction

Thin film technology plays an important role in the high-tech industries [Ohring, 1992]. Thin film technology has been developed primarily for the need of the integrated circuit industry. The demand for development of smaller and smaller devices with higher speed especially in new generation of integrated circuits requires advanced materials and new processing techniques suitable for integration technology [Moshfegh, 2003]. In this regard, physics and technology of thin films can play an important role to achieve this goal. The production of thin films for device has been developed over the past 40 years.

Thin films as a two dimensional system are of great importance to many real-world problems [Seshan, 2003]. Their material costs are very small as compared to the corresponding bulk material and they perform the same function when it comes to surface processes. Thus, knowledge and determination of the nature, functions and new properties of thin films can be used for the development of new technologies for future applications [Aguilar, 2011].

Thin films are thin material layers ranging from fractions of a nanometre to several micrometers in thickness [Sevvanthi, 2012]. A uniform thin film can be applied by different techniques like Chemical Vapour Deposition (CVD) and Physical Vapour Deposition (PVD)[Hussein, 2011]. Another technique is spin coating.Spin coating is a fast and easy method to generate thin and homogeneous films [Dunbar, 1987]. Spin coating is a procedure used to apply uniform thin films to a flat substrate. A machine used for spin coating is called a spin coater, or simply spinner. In short, an excess amount of a solution is placed on the substrate, which is then rotated at high speed in order to spread

M.F. Hossain, Rajshahi University of Engineering & Technology (RUET), Bangladesh
E-mail: faruk94_ruet@yahoo.com

the fluid by centrifugal force. Manufacturing techniques are relatively simple because equipments are available .One of the most important factors in spin coating is repeatability. Several methods to grow inorganic compound semiconductors are taking vital roles in the advancement of technologies. To obtain the performance of thin film based devices control over the film properties is necessary.

Therefore many sophisticated techniques, namely laser assisted evaporation, molecular beam epitaxy, ion beam sputtering, thermal evaporation, vacuum deposition, chemical vapour deposition, sol-gel, chemical bath deposition etc are being used. These processes are energy intensive and involve high temperature, pressure and vacuum. But spin coating is one of the most suitable, cost effective, fast and simple method to deposit thin film and the way of preparing uniform and homogeneous thin films [Schubert, 2003]. In this work, a cost effective and very simple spin coater has been proposed with their modifying base for spinning disk. Our proposed design is approximately 70% cost effective than the market available spin coating system. There is no time consuming delay and it is easy to clean after each operation.

## 2. Methodology

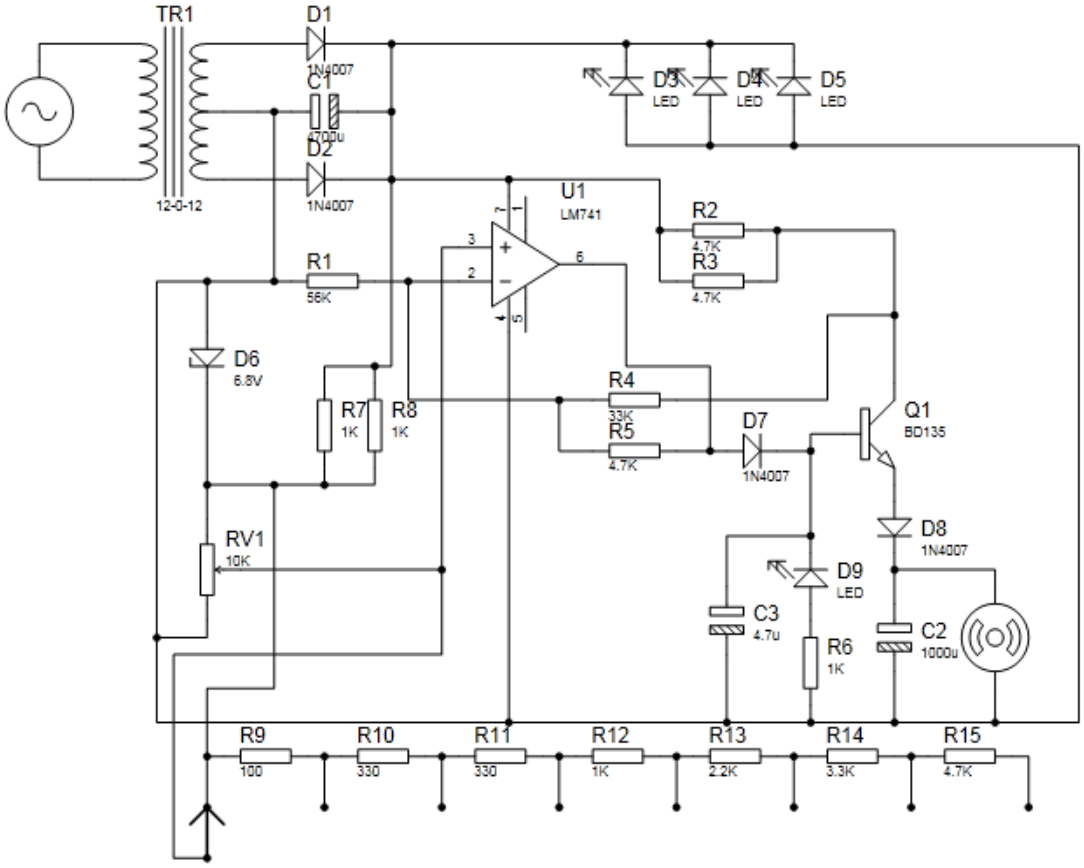
The complete setup of the spin coater is shown in the following Fig. 1.

**Figure 1: Complete Setup of a Simple Spin Coater**

This setup contains a DC motor, regulator, spinning disk, substrate, LED, controlling circuit. The circuit is placed inside the box. In our design 12V, 3800rpm motor is used. To control the spinning speed, a regulator is used for varying the supply voltage from 0 to 12V.

A power supply is built using a transformer connected to the ac supply to step down the ac voltage to desired amplitude, rectifying that ac voltage & then filtering with a capacitor. The connection of the complete voltage supply unit is shown on Fig. 2.

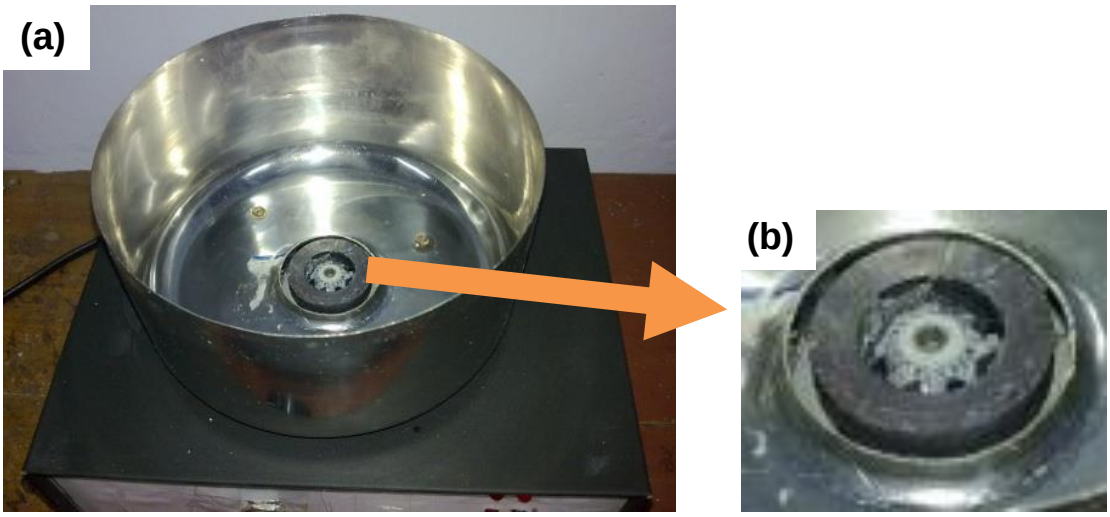
**Figure 2: Internal Circuit Diagram of Spin Coater**




The ac voltage is first stepped down to 12V rms across bridge rectifier. A capacitor filter then provides a ripple free dc voltage. This voltage acts as the input to the voltage regulator [Schubert, 2003]. The circuit and the motor are mounted inside a box with the axis of the motor passing through the upper surface of the box.

The arrangement of a push button, regulator knob and spinning circular disk is made as in Fig. 1. The disk is magnetically attached the motor shaft which can be taken apart. The push button serves as the start button. LED is used for power indication. Substrates are placed on the centre of the flat disk and are connected to the spinning disk using a small piece of double sided adhesive tape.

**Figure 3: (a) A Spin Coater without Spinning Desk; (b) Modifying Base for Spinning Disk.**




The spinning disk of the spin coater is connected to the motor shaft using magnetic contacts. This is done so that the disk can be taken off with ease. In the following Fig. 4, the disk is shown detached from the system.

**Figure 4: Spinning Disk**

The spinning plate and deposition film is isolated from outer atmosphere by a glass cover to avoid sprinkling of the solution. The cover is shown in the following Fig. 5.

The plane of the spinning disk is perfectly levelled with the horizontal. Also the substrate must be clean and free of dust particles. Otherwise the film will not be uniform. This compatible, easy-to-use device provides a convenient step-by-step method for precise & uniform deposition of thin films and coatings.

**Figure 5: Cover of the Spin Coater**

## 3. Spin Coating

Spin coating is a procedure that used to apply uniform thin films to flat substrates such as glass, wafer, and GaAs. In another word, an excess amount of a solution is placed on the substrate, which is then rotated at high speed in order to spread the fluid by centrifugal force. Usually a small amount of coating material is applied on the center of the substrate, which is either spinning at different speed. [Sevvanthi, 2012] By the presence of centrifugal force, substrate is rotated at high speed in order to spread the coating material. The machine used for the purpose of spin coating is called a spin coater, or a spinner. Here the rotation is continued until the film achieves its desired thickness. Usually the applied solvent is volatile, and simultaneously evaporates. For the high angular spinning speed of film become thinner. The film thickness is also depends on the concentration of the solution and the solvent.

Spin coating, a very favorable process, widely used in micro fabrication for creating thin films with thicknesses in nm scale. To get a good quality film this is one of the most reliable and well-known method.

## 4. Spining Steps and Graf

The spin coating technique mainly consists of following four stages [Hussein, 2011]:

- First stage, the deposition of the coating fluid substrate.
- Second stage, when the substrate is accelerated up to its final, desired, rotation speed.
- Third stage, the substrate is spinning at a constant rate and fluid viscous forces dominate fluid thinning behaviour.
- Fourth stage, when the substrate is spinning at a constant rate and solvent evaporation dominates the coating thinning behaviour

- Initial conditions that can be recommended for a good film deposition are the following:

- The spinning disk should be perfectly leveled horizontally.
- The deposited solution should wet the substrate.
- The substrate must be clean and free from any kind of dust particles.
- The solution should be homogeneous and uniform.

The relationship of film thickness with spinning speed and spin time is shown in Fig. 5, and 6, [Hussein, 2011].

**Figure 6: Film Thickness Vs Spin Speed**

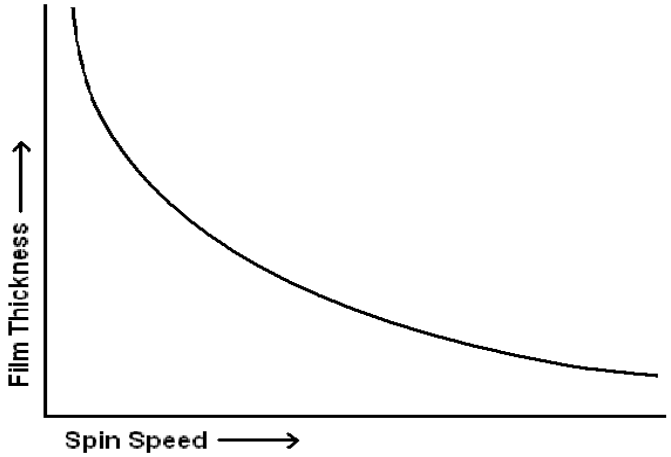
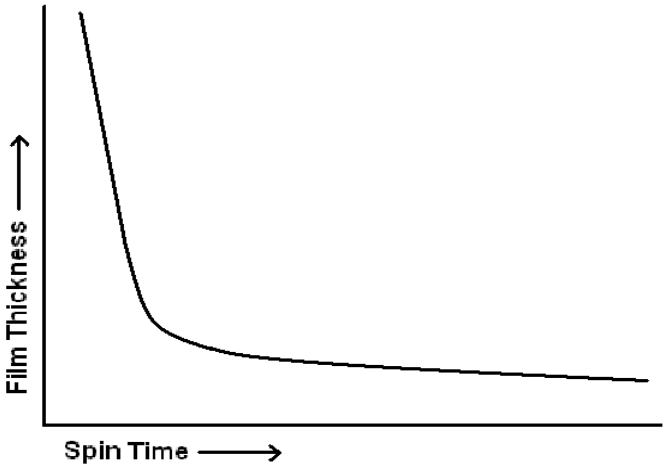



**Figure 7: Film Thickness Vs Spin Time**




There are several methods for the thin film deposition. Among all the advantages of spin-coating methods are: available equipments, no time-consuming delays, fast operating and low cost. The important factors are:

- Fluid viscosity.
- Solution concentration
- Angular speed.

- Spin Time.
- Evaporation rate of solvent.

Applications: In insulating layers for microcircuit fabrication (like: polymers, SOG), microcircuit production, flat screen display coatings, antireflection coatings, in dielectric application and microelectronic industries for the fabrication of integrated circuits.

## 5. Results

By using spin coating method ZnO films are prepared and deposited on glass substrates. The ZnO precursor solution was prepared at room temperature by dissolving zinc acetate dehydrate (Zn (CH3COO)$_2$·2H2O) in ethanol ($C_2H_5OH$) and diethylamine ($CH_3CH_2NHCH_2CH_3$). The solution is stirred about half an hour till it become a clear and homogeneous. The films are prepared on glass substrate at different variation of speed and time. The following ZnO films are prepared by using our designed spin coater:

**Figure 8: Film Transparency Test (Varying Time with Constant Speed)**

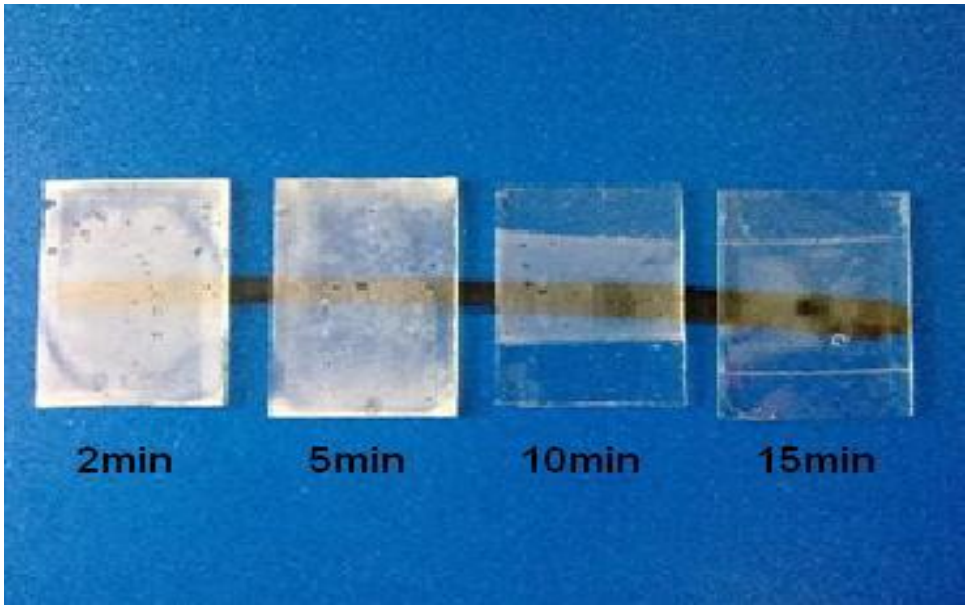
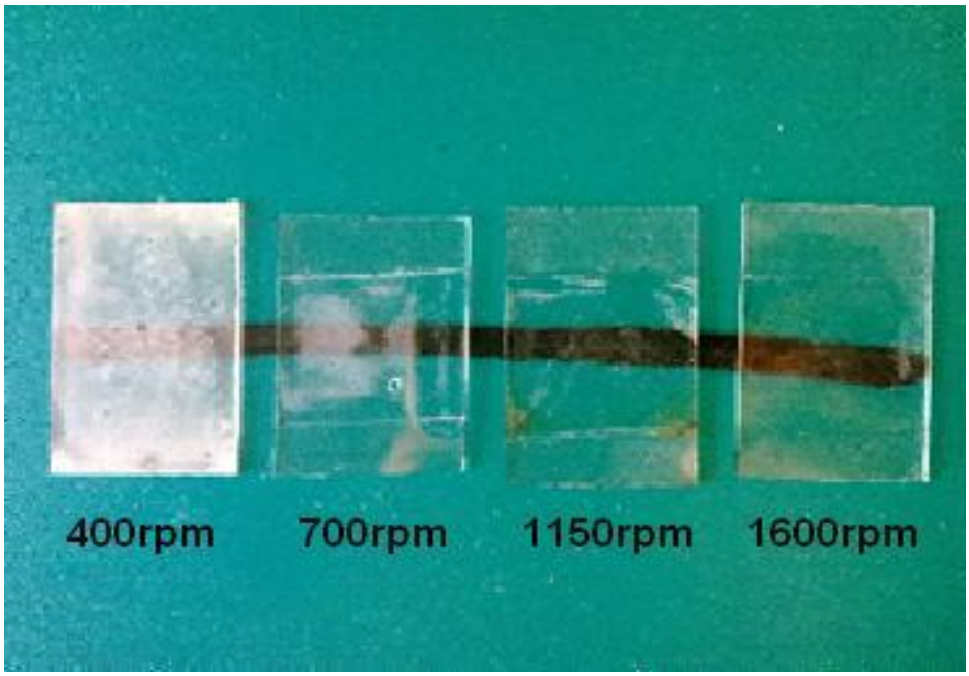


**Figure 9: Film Transparency Test (Varying Speed with Constant Time)**




The ZnO thin films a can be prepared using various methods: sputtering, spray pyrolysis, chemical vapor deposition, pulsed laser deposition, oxidation of metallic films etc. In respect of other methods, the sol-gel spin coating method has some merits such as easy control of used chemical components, deposition of thin films at low cost, less complicated deposition equipments [2].

In above Fig. 7 and 8, film transparency is shown in respect to varying time with constant speed and varying speed with constant time. The transparency is dependent proportionally to speed and time.

In the recent years, ZnO have received considerable attention due to its applications in electrical, optical, mechanical and scientific research as well as industry. ZnO is a wide band gap n-type semiconductor with hexagonal wurtzite structure. It is a versatile material having potential use in many applications like solar cell, transparent conducting electrode, ultraviolet and blue light emitting diodes, laser diodes, thin film transistor, surface acoustic wave (SAW) devices and gas sensors. For transparent conducting application the film should have low resistivity, high transmittance in the visible range and good stability against corrosive environment.

## 6. Future Work

By including microprocessor in the main circuit we can include the auto on/off system. We also can add a digital display to know the speed, time and other necessary readings.

## 7. Conclusions

A cost effective spin-coater was successfully designed and fabricated. The total system is very simple. Spin coaters are ideal tools for the preparation of thin films. In this work, ZnO thin films are successfully prepared by spin-coating method, using a simple and convenient chemical route. This spin coater can also be used for film deposition of different types of precursor solution. To tackle the problem of high instrumental costs, in this work we propose the development of apparatus of easy implementation in the laboratory for the preparation of thin films using recycled electronic components.

## 8. Acknowledgment

Authors would like to thank the Rajshahi University of Engineering & Technology (RUET) for financial supporting to finish this work.

## References

Ohring, M. (1992), 'The Materials Science of Thin Films', *Academic Press limited*, 24-28 Oval Road, London, NW1, 7DX, UK, pp. XIII. Moshfegh, A. Z. Känel, H.V., Kashyap, S.C., and Wuttig, M. *(*2003*),* 'Proceedings of the International Workshop on Physics And Technology Of Thin Films', *World Scientific Publishing Co. Pvt Ltd.* 5 Toh Tuck Link, Singapore, 596224 *Tehran, Iran, pp. IX.*

Seshan, K. (2002), '*Handbook of thin-film Deposition processes and techniques: Principles, Methods, Equipment and Applications'*, 2nd ed, Norwich, New York, U.S.A.: Noyes publications, William andrew publishing.

Aguilar, R.G., and López, J.O. (2011), 'Low cost instrumentation for spin-coating deposition of thin films in an undergraduate laboratory', *Latin American Journal of Physics Education*, 5 (2), 368-373.

Smirnov, M.A., Rambu, P., Baban, C., and Rusu, G.I. (2010), 'Electronic Transport Properties in Polycrystalline ZnO Thin Films', *Journal of Advanced Research in Physics*, 1 (2), 021011.

Sevvanthi, P. Claude, A., Jayanthi, C., and Poiyamozhi, A. (2012), 'Instrumentation for fabricating an indigenous spin coating apparatus and growth of zinc oxide thin films and their characterizations', *Advances in Applied Science Research*, 3 (6), 3573-3580.

Hussein, H.F., Shabeeb, G. M., and Hashim, S. S. (2011), 'Preparation ZnO Thin Film by using Sol-gel-processed and determination of thickness and study optical properties' *J. Mater. Environ. Sci*. 2 (4), 423-426

Dunbar, P., and Birnie, III. (1987), 'The Key Stages in Spin Coating', *J. Imaging Technology*, 13, 122.

Schubert, D.W., and Dunkel, T. (2003), 'Spin-Coating' *J. Appl. Phys*., 49 (7), 3993.