DESIGN AND FABRICATION OF SPIN COATING SYSTEM FOR 8-INCH WAFER

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I certify that except where due acknowledgement has been made, the work is that of the author alone; the work has not been submitted previously, in whole or in part, to qualify for any other academic award; the content of the thesis is the result of work which has been carried out since the official commencement date of the approved research program; and, any editorial work, paid or unpaid, carried out by a third party is acknowledged.

Signature of author Teoh Chin Keng

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LIST OF ABBREVIATIONS

LCD	Liquid crystal display
PP	Polypropylene
PWM	Pulse width modulation
RPM	Rotating per minute
ZnO	Zinc (II) oxide

LIST OF EQUATION

$t = 1/\omega^{1/2}$ (1)

ABSTRAK

Saiz diameter untuk wafer silikon telah meningkat dari 100 mm kepada 200 mm. Pertukaran wafer kepada size yg lebih besar kerana kebaikan dalam kos disebabkan bilangan ketulan bagi setiap wafer. Perningkatan dalam saiz cip dan permintaan merupakan factor perubahan saiz wafer jadi besar. Satu peralatan baru, sistem pelapis berputar dibina untuk melapiskan wafer yang boleh sehingga saiz 8-inci. Alatan penyambungan putaran SMC diguna dalam kerja ini untuk menyambung paip vakum dan plat pusingan. Sistem penyambungan putaran dipusing oleh enjin berkuasa tinggi. Kedua-dua sistem enjin dan sistem vakum dipasang dengan kapi dan dijalin dengan tali sawat. Modulasi lebar denyut diguna untuk mengawal kelajuan enjin manakala pengesan inframerah digunakan untuk mengukur kelajuan putaran. Kelajuan putaran untuk sistem pelapis berputar ialah dalam linkungan 500 sampai 3000 putaran seminit. Satu lapisan yang nipis dilapis atas slaid kaca dan ketebalan lapisan direkod untuk menguji kefungsian sistem pelapis berputar. Sistem pelapis berputar yang dibina mempunyai kepunyaan untuk melapis saiz wafer sehingga 200 mm dan kelajuan boleh ditukar.

ABSTRACT

The size of the silicon wafer has been increased from 100 mm to 200 mm in diameter. The transition of the wafer into bigger size is due to overall cost benefits resulting from the larger number of dice per wafer. Growing in chip size and growing of demand also reasons the transition wafer into the bigger size. A new equipment, spin coater system is developed to spin coat a wafer that can up to size 200 mm or 8-inch. The SMC rotary joint is used in this work to connect vacuum pipe and rotating chuck. The vacuum system is driven by a powerful motor. Both of the motor system and vacuum system are equipped with pulley and connected by a tendon matte belt. Pulse width modulation (PWM) is used to control the speed of the motor while infra-red (IR) sensor is used to track the rotation speed. The spinning rate of the spin coater system varies between 500 rpm to 3000 rpm. A thin film is coated on a glass substrate and thickness of thin film recorded to test the function ability of the spin coater system. The spin coater system that developed has ability to coat a wafer that size can up to 200 mm and the speed is adjustable.

CHAPTER I

INTRODUCTION

1.1 Introduction

Thin film deposition has found growing dramatically in the past few years. It becomes the heart of industries especially in semiconductor industry. A lot of new ideas and innovative of thin film methods are developed for applications in high-tech industries. Thin film deposition can be divided into two main categories which are chemical deposition and physical vapour deposition. Chemical deposition is when a volatile fluid precursor undergoes chemical change on a surface of substrate. The most general example of this process is electroplating. Electroplating is a target surface coated by a layer metal. An ionic metal is supplied with electrons to form a non-ionic coating on a targeted surface. *Figure 1-1* shows electroplating process. A metal is placed at cathode while coating material, copper is placed at anode and chemical solution copper (II) sulfate is used. In the process, copper is oxidized at anode and losing two electrons to form Cu^{2+}. Cu^{2+} is reduce to metallic copper when two electrons are supplied at cathode. A layer of copper is formed on the surface of metal at the end of process. Other example of chemical deposition include chemical vapour deposition, Sol-gel and metal-organic chemical vapour deposition (MOCVD).

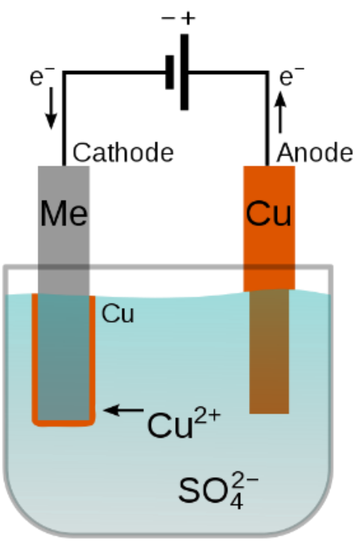

Figure 1-1: Electroplating process.

In physical vapour deposition (PVD), film is form on the surface of target material physically by means mechanically, electromechanically or thermodynamically. The processes are carried out where solid metal is vaporized and deposited on substrate under vacuum condition. There are three basic types of physical vapour deposition which are vacuum deposition, sputtering and ion plating. In vacuum deposition, the metal is evaporated into gas and deposited on the surface of substrate. In sputtering, inert gas is filled in chamber and ionized by electric field. The positive ions from inert gas are then bombard on coating material which places at anode and cause the sputtering of coating material's atoms. The atoms is dense on substrate and heat applied to improve bonding. *Figure 1-2* shows sputtering process. Ion plating is combination of both these processes. The electric field cause a glow and generating a plasma. The vaporized atoms of plasma are ionized partially. The atoms are bombarded and coated on the surface of substrate [1].

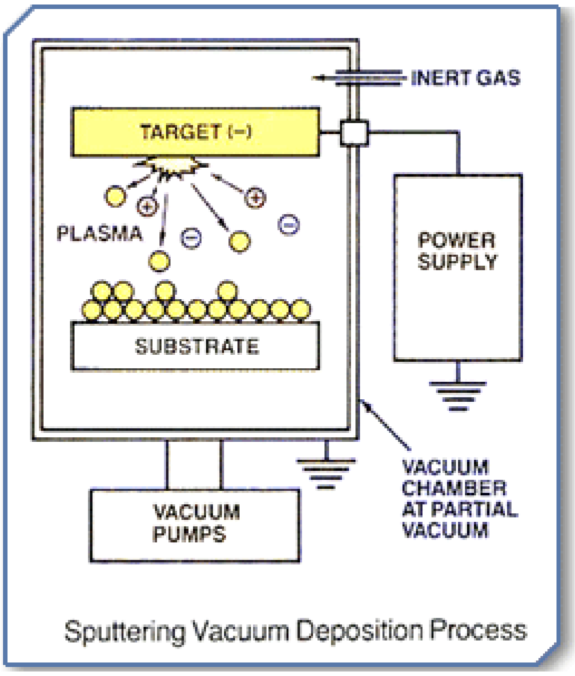

Figure 1-2: Sputtering process

Compare to method that listed, spin coating technique is most common and low cost way to achieve thin film deposition. In spin coating process, a small amount of coating material is drop on the centre surface of substrate. The substrate is then rotate at high speed in order to spread the coating material by centrifugal force. The process coating thin film and set up relatively easier. The thickness of film is flexible by changing the spinning speed and less hazardous technology. In spite these benefits, some drawbacks include large substrate cannot be spin at high spin speed and low material use efficiency where only about 2 to 5 % of coating material is used. But, in overall, spin coating method still consider as a good method to undergo thin film deposition [2]. In semiconductor industry, spin coating is most general method to coat thin film on wafer due to the advantages.

The coated substrate, silicon wafers are the basic material in integrated circuits and solar cells [3]. Almost all electronic devices today power by integrated circuits and use plenty amount of wafers. Due to high demands, the size of wafer getting bigger which means the more microchips it can hold. As a result, the process time and material waste will be reduced. New equipment or bigger spin coating system is needed to work with bigger wafer. Thus, in this work, a spin coating system is fabricated to coat wafer that can up to 8-inch.

1.2 Research Background

Semiconductor industry become more challenging recently. To keep up with customer demand and remain competitive in this field, many companies are trying to reduce the size of electronic devices while lowering cost and maintaining high quality. Thus, one of the action has taken is transition of silicon wafers to bigger size. Bigger size of silicon wafers can reduce production costs and more chips are available for manufacturing. Big company such as Intel, Samsung and TSMC began promoting the need for a transition from the current standard silicon wafer size to the new 450 mm wafers. The size of wafers increased past 4 decades. From *Figure 1-3*, the size increased from 100 mm at year 1975, 200 mm at year 1990 to 450 mm at year 2017. However, not all company can afford move to new 450 mm wafer size. The transition size of the silicon wafers causes large amount of cost especially changing of expensive processing tools and equipment. Extreme ultraviolet lithography or EUV tools and lithography equipment, for example, are more expensive than traditional 193 nm ArF lasers. [4]

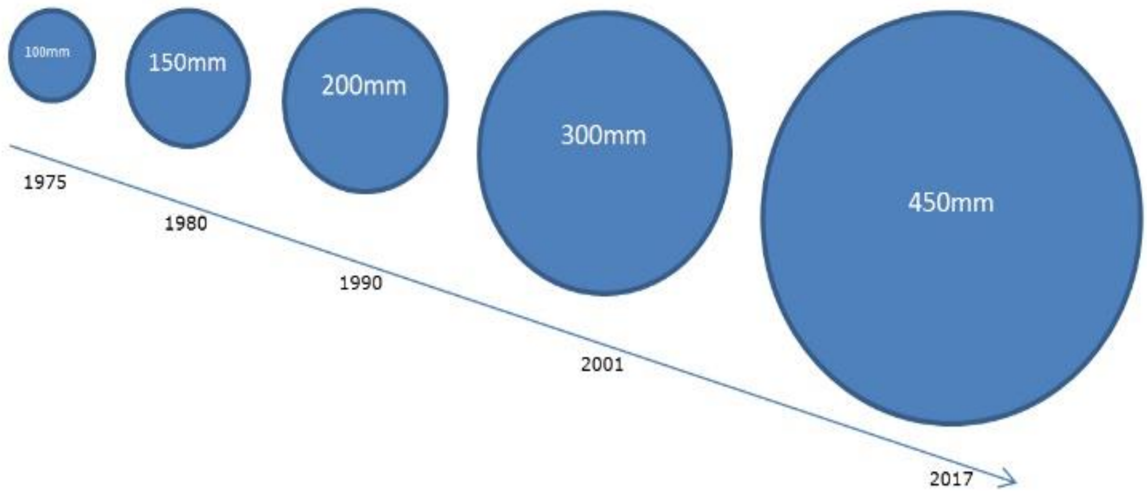

Figure 1-3: Transition size of wafers against timeline

Another example is thin film deposition process. Spin coating is most common method in coating thin film on the substrate. It is easy to use and control. The thickness of film can be control by changing speed of spinning, acceleration, spin time and viscosity of the solution. Besides, due to the capability to spin in high speed and high airflow lead to fast drying times, which in turn results in high consistency at both macroscopic and nano length scales [5]. Changing the size of silicon wafer to bigger size will lead to change of spin coating system. The size of mounting, vacuum performance and spin acceleration depended on the size of wafer. Thus, transition size of wafer will causes company to spend certain amount of money in changing film deposition process equipment.

In many laboratories, spin coating method always are the equipment used to fabrication thin film on substrate. However, not every laboratories can afford to change spin coating system due to change of size of substrate. Furthermore, many commercial spin coaters are expensive and may have features that not necessarily needed for fabrication of thin films. The cost of commercial spin coaters are higher due to extra and unnecessary features. For example, the drain bowls that equip on commercial spin coaters are used to store chemical waste. However, this will bring harm to health when these chemical waste accumulate for a long time. It will be better if such chemical waste can be disposed immediately instead of store in drain bowls [6]. The current work present a design and fabricate a low cost spin coater that capable to work up to 8-inch wafer.

1.3 Problem Statement

The electronic devices become more complex and smaller. Despite this, silicon wafers are the basis for most electronics today. Silicon wafers power everything from supercomputers to small devices such as mp3 player. The size of wafers becomes bigger and up to 12-inch today. The bigger size of wafers can increase throughput and reduce cost production. To follow this trend, 8 inches wafer is used instead of 4-inch wafer in the lab. However, the current spin coater system available in the lab only capable to coat 4-inch wafer. Hence, a spin coater system that can work up to 8-inch wafer is developed.

1.4 Objectives

- To design and develop a spin coating system that can coat a wafer up to size 8-inch.
- To fabricate an inexpensive and open source software spin coating system compare to commercial spin coater.

1.5 Scope of Work

The scope of this work in the design phase is the 3D part modelling the spin coater system by using SolidWorks. Due to limit budget, some parts of the spin coater system are using the material available from workshop in school. While some parts such as motor, SMC rotary union and electric components are ordered from online and shops. To fabricate the system, the facilities and equipment available in the workshop are required. The facilities and equipment include drill machine, milling machine, puncher and file to smooth the rough surface. Finally, performance of the spin coating system is tested by measure the thickness of thin film layer and then compare with theoretically result.

CHAPTER II

LITERATURE REVIEW

2.1 Introduction

The previous chapter outlined the background and objectives of this research. This chapter will start with review the process in semiconductor manufacturing. The semiconductor manufacturing is a process to produce wafer chip start from silicone until integrated device is completed. In section 2.3, the spin coating process is discussed. The step begins with spin coat substrate until thin film is completely coated. The commercial spin coater available in the market and the homemade spin coater is reviewed in section 2.4. Comparison between pricey commercial spin coater and inexpensive spin coater is made. Section 2.5 discuss about the various method of experiments that used to test the performance of a spin coater machine.

2.2 Semiconductor Manufacturing Process

Semiconductor manufacturing is the process to produce semiconductor devices such as computer and smart phone. The process is start from raw material which is silicon (sand) that available anywhere on earth crust until the electronic device is complete. However, the fabrication of chips from silicon (sand) is still less widely known. There are nine main steps in order to complete semiconductors manufacturing process. The overall flow of semiconductor manufacturing process is shown in *Figure 2-1*. The first step is wafer production where a purified polycrystalline silicon, created from sand is melted into molten and single crystal ingot is formed after seed is pulled from molten. The ingot is then cut into thin wafers slide by diamond slice tool and undergoes series of finishing process to polish the wafer’s surface.

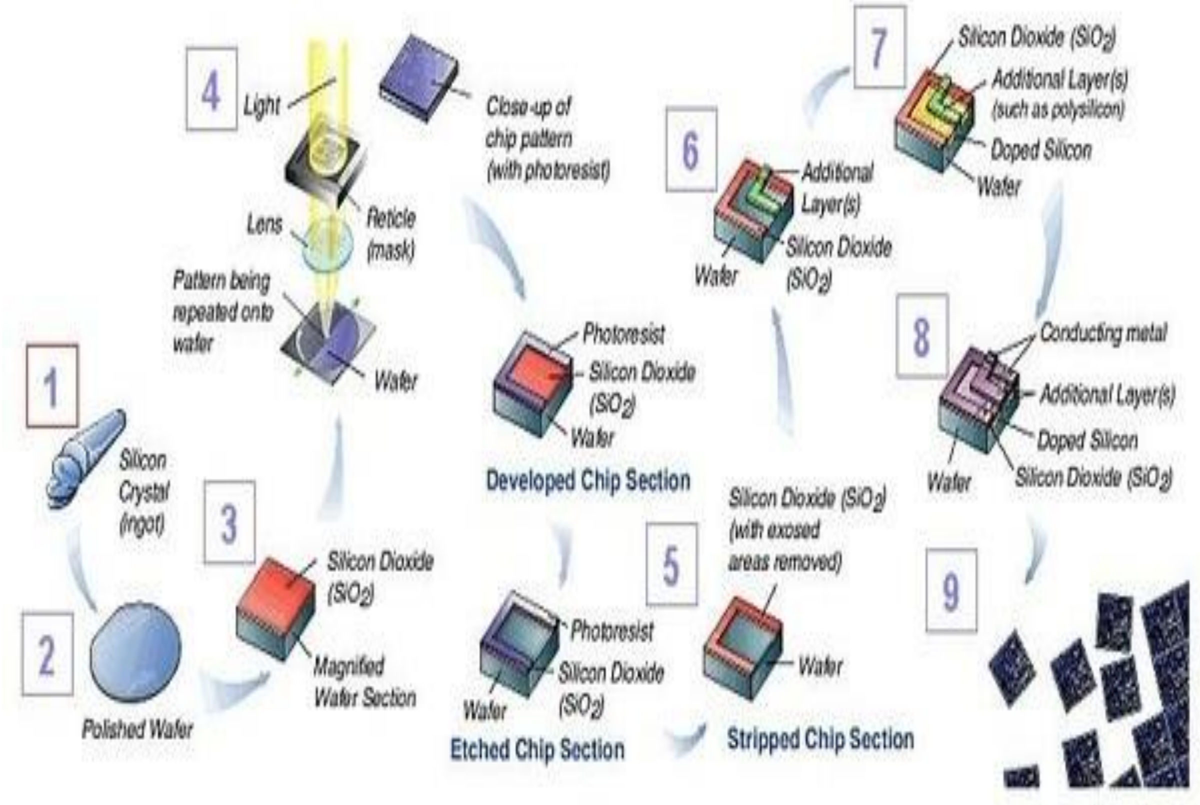

Figure 2- 1 Overall process of semiconductor manufacturing

The second step is thermal oxidation or deposition. Wafer is cleaned by using chemical solution such as Acetone and heated to form an oxide layer or called silicone dioxide (SiO_2). Next step is masking process. The wafer is coated with light sensitive photoresist by spin coating process. The thickness of film layer is depend on the duration and spinning speed of spin coating system. Besides, other parameters such as acceleration, concentration and viscosity of coating material will also affect the thickness result of thin film. The substrate is then exposed to light to transfer mask pattern.

The fourth step is etching process. The wafer is undergo soft bake after photolithography process. The coated substrate is baked on heater to remove excessive solution and harden the thin film layer. The substrate is then developed to remove unwanted photoresist layer. After that, wafer is exposed to chemical solution or plasma to etch away the place that not cover by hardened photoresist.

Doping is the fifth step of the process. N-type or p-type dopant is introduced into the etch area. Atom with less one electron like boron called n-type dopant while more one electron is called p-type dopant. The dopants or impurities added to silicon wafer to change the electricity properties. The previous steps were repeated until top layer was completed. The fifth step is dielectric deposition and metallization. Dielectric layer (SiO_2) and metal are deposited to create interconnecting between each pole as shown in *Figure 2-2*.

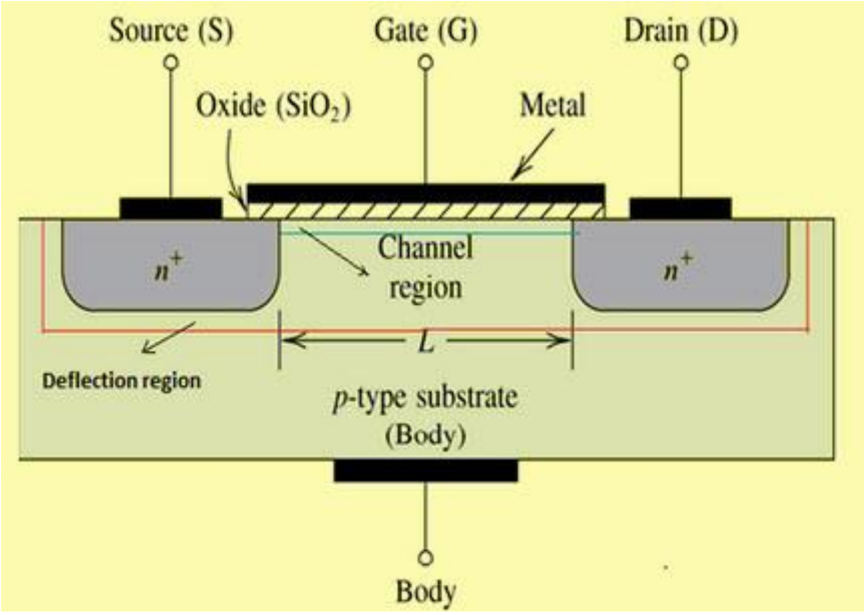

Figure 2- 2: Metal and insulator are deposited on surface of substrate to connect between source and drain.

The following step is passivation which a final dielectric layer is deposited to protect circuit from contamination and damage. Electric testing is done in order to check the functionality. The wafer chip may face functionality failure during fabrication process. Thus, electrical test such as open and short test are used to test functionality of wafer chip. Final step is the chip assembled into a package and wire bonding to connect between chip and package. The chips are wire bonding to package so that protect from damage. Furthermore, heat management of chip after packaging will be improved. [7].

2.3 Spin Coating Process

Spin coating is one of important process in semiconductor manufacturing process. During spin coating process, coating material on the substrate thins by convective outflow driven by centrifugal force. Spin coating is a batch process. From *Figure 2-3*, the coating material will drops on the surface of substrate either in stationary or spinning at low speed. The substrate will be spin and accelerated to specific speed. During spinning process, the coating material will fling off to the corner of substrate. If the coating material not fully cover the substrate during spinning process, more coating material can be drop on the surface. Majority coating material is dried by airflow when spinning. The coating material is undergoing evaporation although the spinning process stopped. If the topography of substrate is not uniform, diffusion driven convection can redistribute the non-volatile solids over the topographical features. [8]

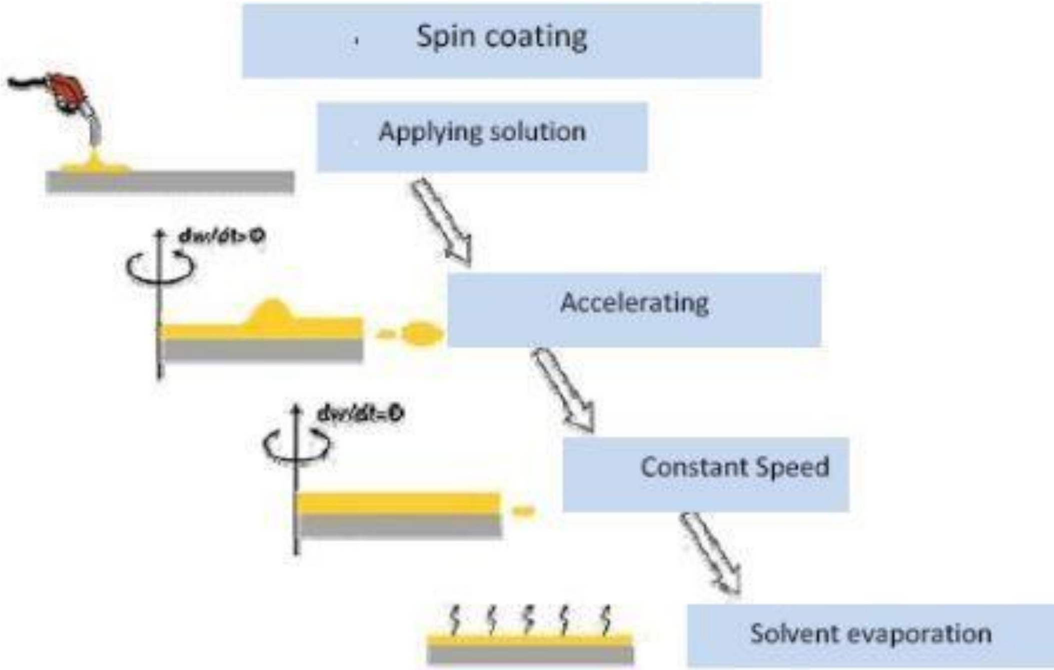

Figure 2- 3: Procedure in spin coating process

The thickness of thin film depend on the spinning rate greatly. When spinning rate increases, the thickness of thin film will be decreased. The thickness of thin film and spinning rate is generally given by

$$t = 1 / \omega^{1/2} \quad (1)$$

where t is thickness of film layer, ω is spinning rate. [9]

The applications of spin coating can be used to coat glass slide until big product such as solar panel. The material of coating substrate can be insulator, organic semiconductors, metal, nano-material and so on. In conclusion, spin coating is one of best method to coat thin film on the substrate. It is easy to set up and flexible in controlling thickness of thin film.

2.4 Spin Coater System

A machine that used for spin coating process is called a spin coater. There are many commercial spin coater seller available in the market such as Laurell Technologies Corporation, Apex Instruments Corporation and Suss Microtec Corporation. Most of commercial spin coaters are very expensive (more than USD 2000) and the price is depend on the capability diameter of substrate to be coated and highest spinning rate. Commercial spin coater generally used vacuum force to hold substrate. Other additional feature include drain system and calibration option.

The Laurell H6-8 spin coater (*Figure 2-4*), is a spin coater that can work on 8 inch wafer. The maximum rotation speed for this machine can up to 12 000 rpm (based on 100 mm silicon wafer). Housing for this machine is made from a solid PTFE Hostaflon which is a specific type of Teflon that only exclusive to Laurell Technology. Teflon or known as polytetrafluoroethylene (PTFE) is a particularly versatile ivory-white and opaque plastic fluoropolymer. The applications of this material can be in aerospace, food and drink industry and pharmaceuticals. PTFE is chemically inert and thermal resistant. It also is non electrical conducting material and is non-stick. The melting point temperature of PTFE is 327°C [10]. Laurell H6-8 use vacuum sucking force to hold substrate. Besides, motor and electronics devices in this machine are protected from coating material by labyrinth seal. This seal also provides the process chamber with Nitrogen purge. One of main focus of this machine is it equipped with wireless controller which allows operator control the machine in real time, from anywhere inside the range including stopping and program controlling. Other features include multiple automated dispenser and transparent lids [11].

Figure 2- 4: Laurell H6-8 8 inches spin coater with wireless control

Another example for commercial spin coater is SpinNXG-P1A (*Figure 2-5*) from Ape Instruments. The spin rate is lower than previous machine which can spin in the range 100 to 10000 rpm. It uses brushless DC motor and can accelerate between 40 to 5000 rpm per second. The casing of the machine is made from aluminium while working chamber is made from Teflon. Input and controlling through key-pad. Same with Laurell H6-8, SpinNXG-P1A uses vacuum sucking force to hold the substrate. It also equipped with transparent lid with photoresist safety and dispensing port [12].

Figure 2- 5: Apex Spin NXG-P1A spin coater

Compare to pricey commercial spin coater, homemade spin coater is far cheaper. Most of commercial spin coater is expensive due to externally features and specifications which are not necessarily for fabricating and experimenting. High cost of such instrument may act as an obstacle for certain groups of people or organization who intending to fabricating and experimenting with simple devices. Thus, idea to design an inexpensive spin coater was come out. There are many published works and examples regarding design an inexpensive spin coater. In V. H. G. David Loza M., Reza Dabirian, 2014 [6], the spin coater is able to spin range from 300 rpm and 10000 rpm. 12V brushless DC motor is used and the rotating disk on which the sample is deposited. To control the spinning speed, pulse width modulation (PWM) is used together with Arduino microcontroller. L298N shield used to connect between microcontroller and the Arduino DC motor. The Arduino is used to receive data from user interface, process the data and to send it to the DC motor. Substrate is put on rotating disk by using double-sided tape. From *Figure 2-6*, an acrylic enclosure is used as spin bowl. The motor is placed in mild steel holder and hold by cable tie.

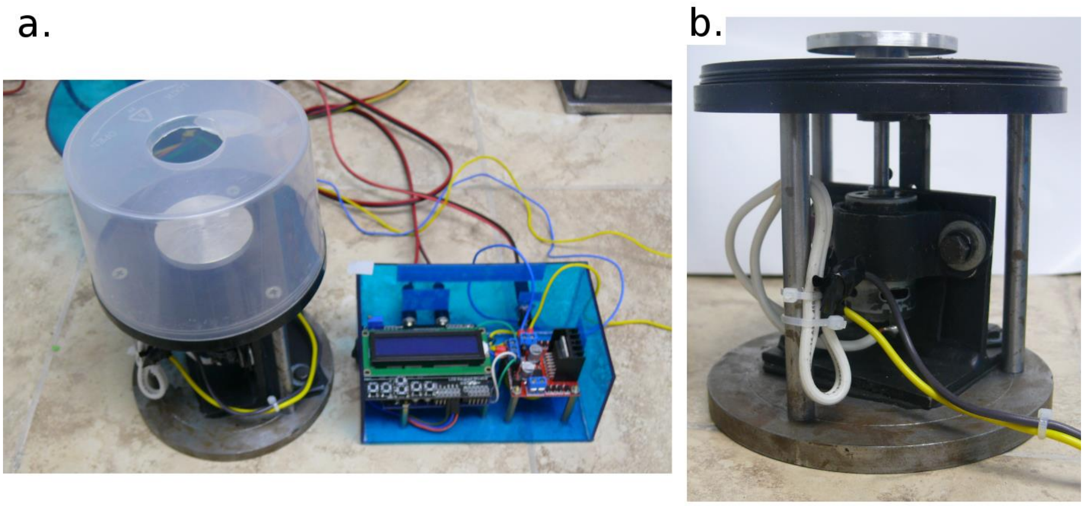

Figure 2- 6: (a) Overview of spin coater (b) A closed view motor that used.

For M. F. H. Mohua Fardousi, M.S. Islam and Sharik Rahat Ruslan, 2013 [13], a 12V DC motor was used and can spin until 3800 rpm. A regulator is used for varying the supply voltage and a power supply is built using a transformer connected to the ac supply to step down the ac voltage. A spinning circular disk was made and magnetically attached to the motor shaft. Substrate is then placed on top of spinning disk by using double sided tape. From *Figure 2-7*, a cooking pot was used as spin bowl. All the motor and electric circuit are stored inside a casing. A drawback for this work is performance of substrate may affected due to attachment of double side tape.

Figure 2- 7: Overview of spin coating machine using pot as spin bowl.

A DC motor which can spin range between 200 to 6500 rpm is used in K. K. S. C.Thirunavukkarasu1, B.Janarthanan3, and J. Chandrasekaran4, 2016 [9]. The spinning rate is controlled by using potentiometer. A substrate holder is made on the spinning disk. A transparent chuck is then place on substrate holder to avoid sprinkling of the experiment solution. The substrate is placed and fit in the chuck *Figure 2-8.* For the electric circuit in *Figure 2-9,* the input AC voltage step down to 12V AC and given to the bridge constructed using four diodes. The output of bridge rectifier with ripples is filtered by capacitor and output DC voltage is fed into ICLm317T. This IC is used to regulate spin rated along with ten thousand Ohm potentiometer.

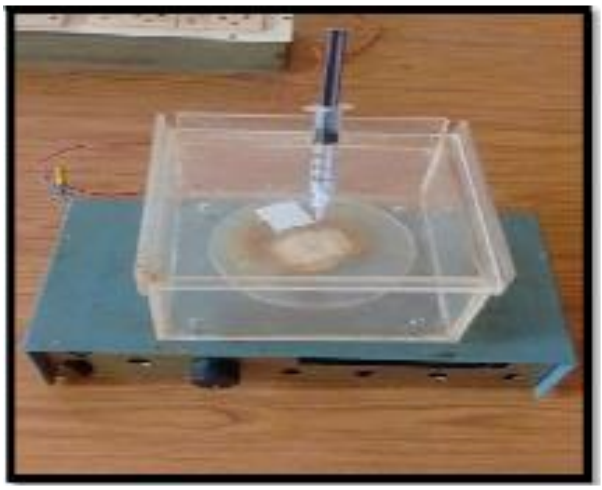

Figure 2- 8: The syringe used to drop solution on substrate in chuck.

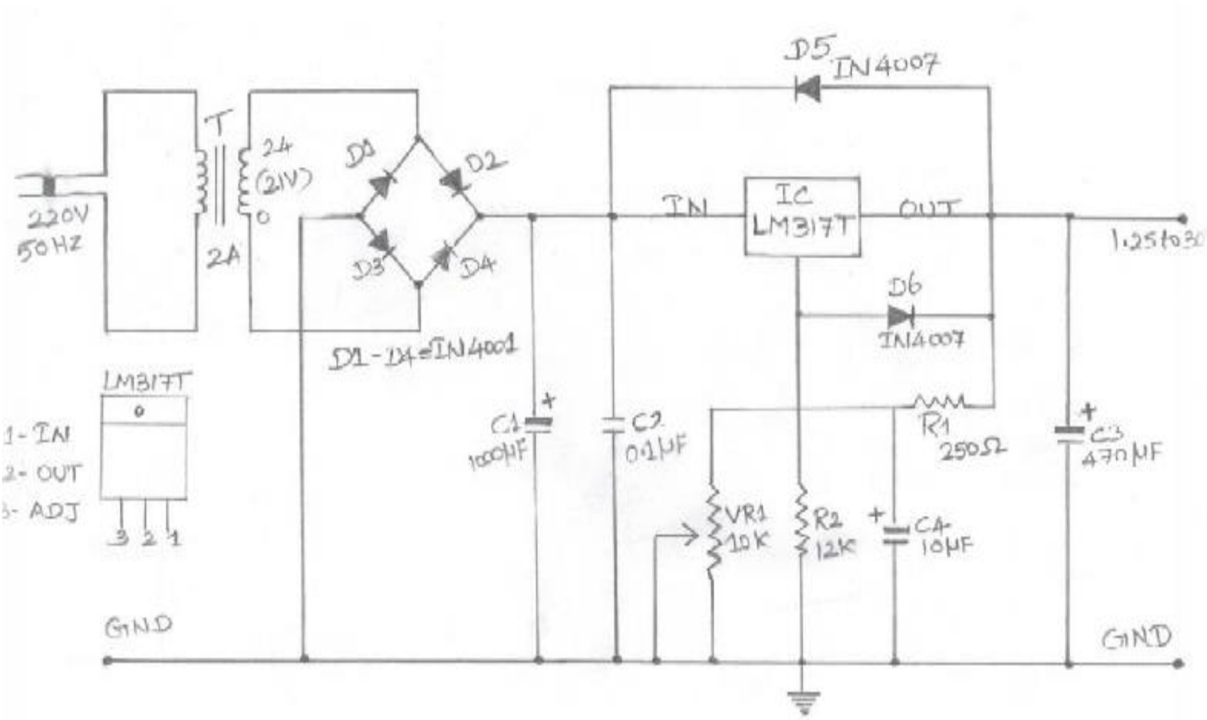

Figure 2- 9: Schematic diagram to variable power supply (0-30V)

Drive by DVD motor is used in J. O. L. Ramón Gómez Aguilar, 2011 [14]. Spin rate for DVD drive can used up to 11000 rpm. From *Figure 2-10*, the circuit and motor are placed inside a rectangular box. The substrate attached to the supporting disk by using double side tape. A petri dish is used to avoid sprinkling of solution. An integrated circuit L293DD-SO of SGS-Thomson Microelectronics is used. The high current four channel driver design to accept standard diode to transistor (DTL) and transistor to transistor (TTL) logic levels and drive inductive loads. A programmable integrated circuit PIC16LF876A coupled with a fata bus LCD display to view the selected parameter. Programmed interface controller (PIC) is programmed to change the speed as shown in *Figure 2-11*.

Figure 2- 10: Overview design of spin coater using DVD drive

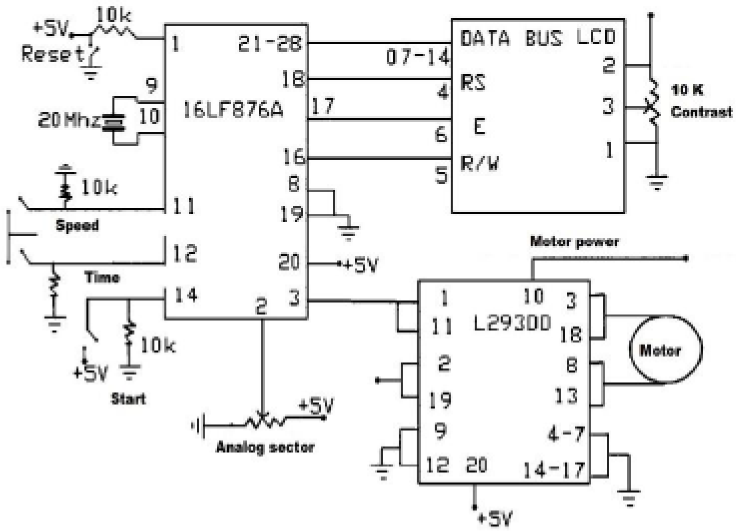

Figure 2- 11: *Schematic diagram that used to control the DVD drive motor*

In R.F. Bianchi c, M.F. Panssiera b, J.P.H. Limaa, L. Yagura b, A.M. Andrade a, and R.M. Faria b, 2006 [15], a brushless DC motor of hard disk drive (HDD) is used. To control spin rate of brushless dc motor, a start-up circuit (*Figure 2-13*) where the signals from rotor position is acquired using back- electromotive force (EMF) sensing technique. Logic control was written and loaded in PIC 16F8&& microcontroller. Current is controlled by a drive bipolar circuit in full wave commutation mode without position sensor. From Figure 2-12 (a), the glass protector is used to protect from spreading of solution. A vacuum pump is used to hold the substrate. From Figure 2-12 (b), the bearing is used to hold the statically vacuum while the HDD base is rotating.

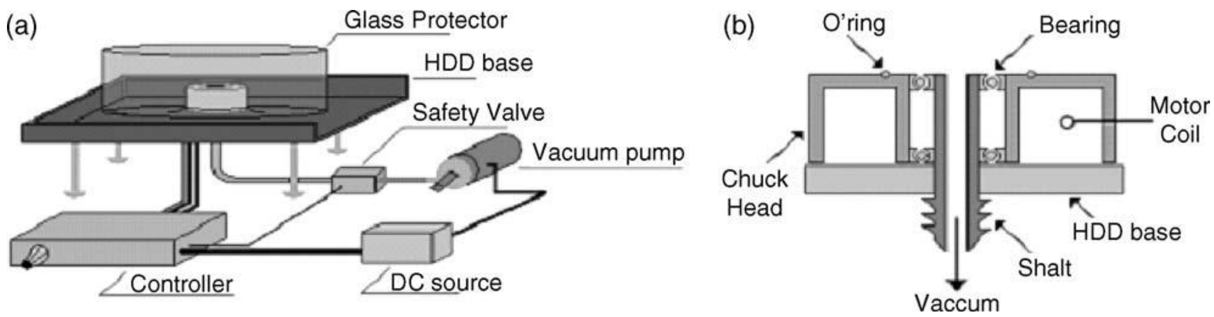

Figure 2- 12: (a) Design of spin coater (b) Detail view of rotor added with vacuum chuck

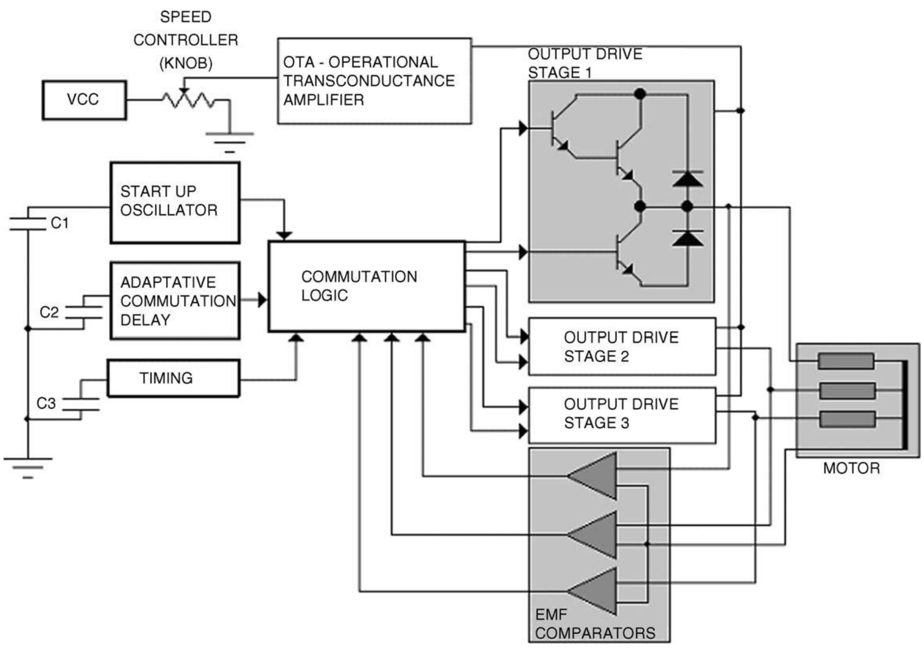

Figure 2- 13: Schematic diagram to control HDD motor.

2.5 Performance Testing

There are a lot of methods to test the performance of spin coater. However, the most generally way is measure thickness of polymer against spindle speed. R.F. Bianchi c, M.F. Panssiera b, J.P.H. Limaa, L. Yagura b, A.M. Andrade a, and R.M. Faria b, 2006 [15] present a work regarding to measure thickness thin poly (o-methoxyaniline) (POMA) films against spinning speed. Five curves with different spinning speed (a.9300, b.5900, c.3500, d.1200, e.660 rpm) were used to in the experiment. The solution is coated on glass substrate and spin about 30 seconds for each spinning speed. After that, the thickness is measured using scanning head system and digital oscilloscope (Alfa Step 500 of Tencor Instruments).

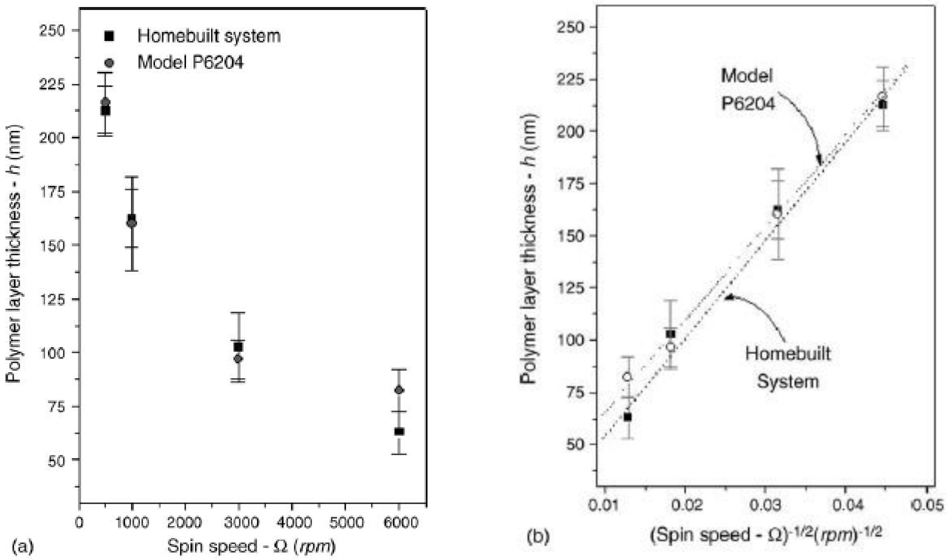

Figure 2- 14: Thickness of POMA against spinning speed of homemade spin coater and commercial spin coater (a) against spin speed (b) against square root of spin speed

From the *Figure 2-14*, the thickness of polymer layer is decreased when spin speed increase. Besides, the performance spin coater that fabricated is almost the same to the commercial spin coater model P6204.

Other than that, the spinning speed against the time is also measured. From *Figure 2-15* the machine took about 0.1 seconds accelerate to achieve the target speed and achieve stable speed.

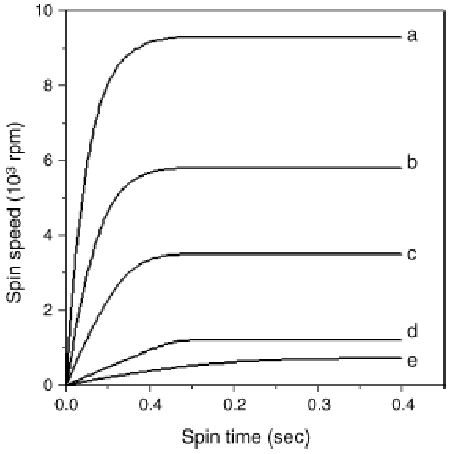

Figure 2- 15: Time taken to accelerate and achieve spin speed

While in K. K. S. C.Thirunavukkarasu1, B.Janarthanan3, and J. Chandrasekaran4, 2016 [9], zinc oxide (ZnO) is coat on the glass substrate. The thickness is then analysed and observed. In the experiment, ZnO films are prepared with different spinning speed which are 500, 1000 and 1500 rpm for 60 seconds.

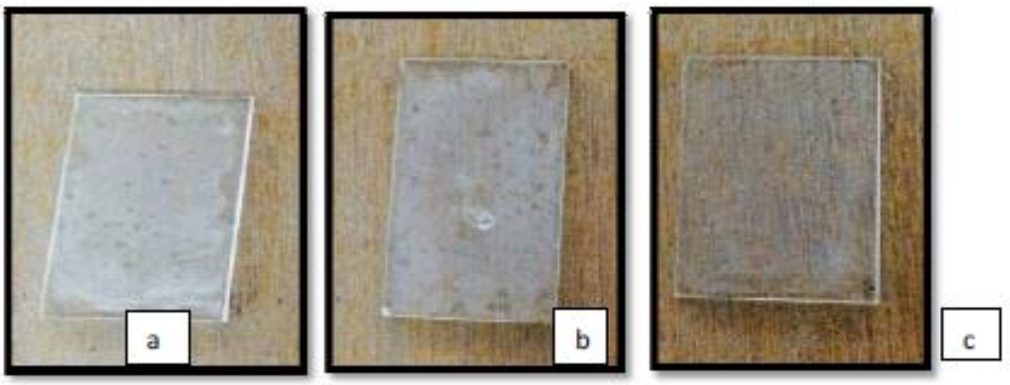

Figure 2- 16: ZnO thin films with different spinning speed, rpm (a) 500, (b) 1000 and (c) 1500

From the result in *Figure 2-16*, spinning speed in 500 rpm has highest thickness. There is a thick white milky layer on the surface of glass substrate. Spinning speed in 1500 rpm has lowest thickness due to less ZnO on the surface of substrate.

CHAPTER III

METHODOLOGY

3.1 Introduction

This chapter details the processes to fabricate a spin coater system that can work up to 200 mm wafers. There are four sections of this chapter which are mechanical design, electrical design, costing, and system performance testing. In section 3.2, a discussion was made in the mechanical design of the spin coating system which includes the design of the system and material and equipment used. Section 3.3 provides a discussion of the electrical and control system design. It includes the electrical circuit design, the control system used and Arduino software. Section 3.4 provides a detail about total estimate cost that used to fabricate the spin coating system. Finally, performance testing of the spin coating system is done to measure the thickness of the substrate.

3.2 Mechanical Design

The design of the spin coating system would resemble with normal spin coating system as closely as possible. Some researchers on a standard spin coating system’s parameters and boundaries have made before starting conceptual design. A typical spin coating system.

- Able to control the spinning speed
- The range of spin speed is 500 rpm to 3000 rpm
- Duration can up to one minute

Besides, in this work, the system should be able to spin coat 8-inch (200 mm) wafer. The substrate is held by sucking force of vacuum. The detail design of spin coating system can refer to Appendix A.

3.2.1 Conceptual Design

Spin Bowl: The purpose of the spin bowl for spin coating system is to prevent chemical solution and substrate flung to surrounding during the spin coating process. Besides, the spin bowl is used to collect coating material that spin-off from the substrate. A few ideas were suggested such as bowl made from Teflon shape by milling process and aluminium sheet was fold and welded into a bowl shape. In the end, a cooking pot was used as the spin bowl for spin coating system. This was because of cooking pot easy to get and save time compared to other methods. The size of pot must be big enough to place 200 mm wafer and there was more space for user able to set up the substrate. The pot was also durable enough to protect the user from the substrate that spin-off from the holder. Furthermore, the pot was made from aluminium, thus the user can easily to clean the bowl after collecting coating material. A hole was create as the outlet when cleaning the pot (*Figure 3-1*). (refer Appendix A for detail drawing)

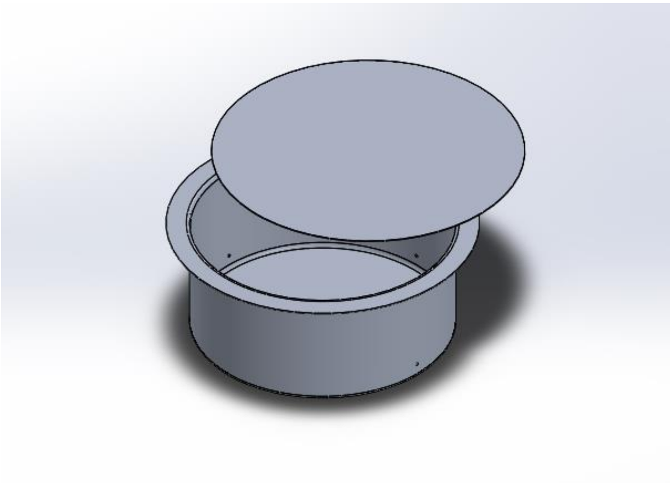

Figure 3-1: Aluminium spin bowl with closure

Casing: The casing is used to encase components and protect components damage from threat surrounding. This is critically important when comes to encase electric components and motor unit. Those components will face working failure once hit by an object and by the spread of water. Besides, the casing as frame body to support the spin bowl. Thus, the casing needed to be strong enough to protect the components and as a framework to support spin bowl. The square shape casing was designed. The size of casing was 500 mm x 450 mm x 200 mm (length x width x height). Two materials which were mild steel (2 mm) and polypropylene (PP) hollow plate used to make up the casing. The front and back side of casing were used PP hollow plate while remaining sides used mild steel. This was because the hollow plate is much easier to machine compare mild steel. A square slot was cut for install LCD display at the front plate. Two slots were milled at the bottom plate so that power unit can be adjusted to tighten the belt. All the plates were connected each other with brackets and bottom of casing was supported by four rubber stoppers (*Figure 3-2*). (refer Appendix A for detail drawing)

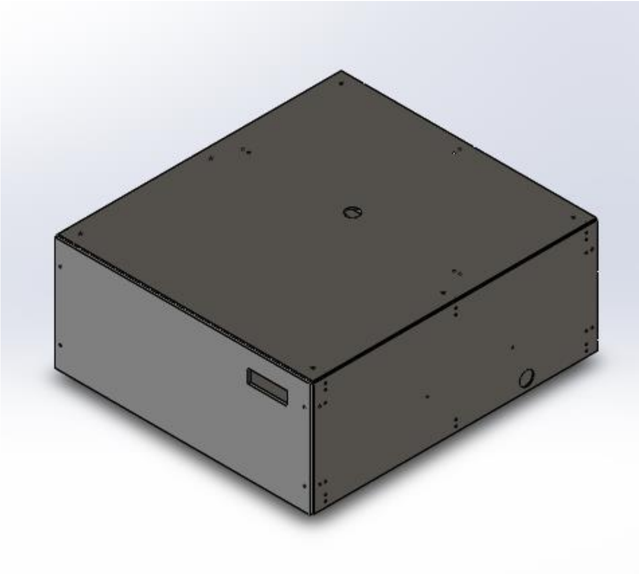

Figure 3-2: Casing that used to store power unit and vacuum unit.

Power Unit: In order to achieve specification, the capability of a motor is very important. The torque of motor doesn't need to be high but required high spin speed. There were several options in choosing motor include by using old computer hard disk, the motor of DVD player and motor from car toy. However, after some considerations, the motor used in this work was a DC motor and purchased from online which had the capability to spin until 10000 rpm. The motor connected by coupling with a bigger shaft and installed a pulley to the shaft. In order to hold the motor and withstand pulling force, holder and supporter were built. Initially, the holder of the motor was built by two 10 mm x 10 mm diameter aluminium hollow square rods. However, the power unit vibrates vigorously when the motor was running. Thus, two aluminium plates with thickness 10 mm were used and built on top of motor base mild steel plate. The shaft supporter was built on top of the holder and the top plate supporter installed bearing. The supporter was built to hold the shaft so that not bend easily when tightening the belt. All of the plates were connected each other by using brackets *(Figure 3-3)*. (refer Appendix A for detail drawing)

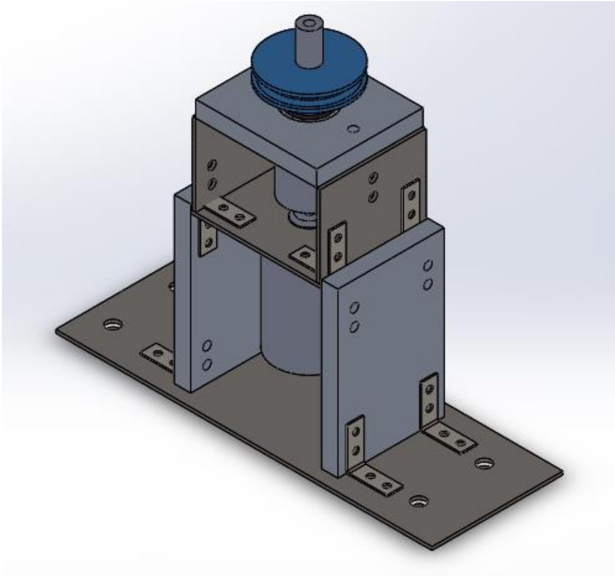

Figure 3-3: Power unit that used to drive vacuum unit

Vacuum Unit: For this work, vacuum was used to hold the substrate. This was because by using vacuum suction force, the substrate especially wafer won't be scratched and the performance of chips will not be affected. Besides, the vacuum force hold the substrate stronger than conventional way which using double side tape. In order to connect with statically vacuum air inlet and to spin the substrate, rotary union was used. The rotary union is a mechanism used to transfer fluid or air that under certain pressure from stationary inlet to a rotating outlet. The upper part or lower part either one part can be in rotating or stationary. The rotary union was placed on top of holder plate and the connected with base shaft. The base shaft is made by rapid prototyping due to easy and save time to fabricate the part. The shaft is then connect to upper shaft and finally to the chuck. Supporter of vacuum unit was built to support the base shaft from pulling force. The side plates were made from mild steel while the top plate was made from 8 mm thick aluminium plate. Bearing was installed to top plate and centre with base shaft. Another upper shaft was then connected to the base shaft. (*Figure 3-4*) (refer Appendix A for detail drawing)

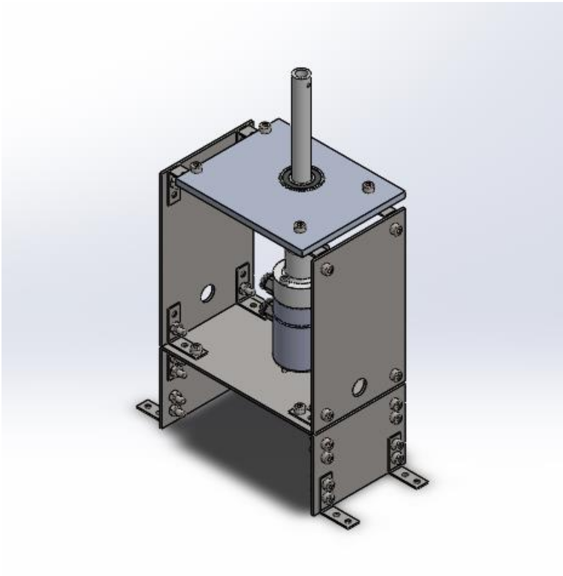

Figure 3-4: Vacuum unit that use to provide suction force

Chuck: The chuck is used to hold the substrate securely in place by friction and centrifugal force. The chuck was made from Vero White and fabricated by rapid prototyping. There were two different diameter of O-rings on the chuck to protect substrate from scratched and prevent vacuum air leakage. The size of chuck was 45mm in diameter and there was a 8mm diameter hole at the centre to let vacuum air flow. The chuck was connected to upper shaft. *(Figure3-5)* (refer Appendix A for detail drawing)

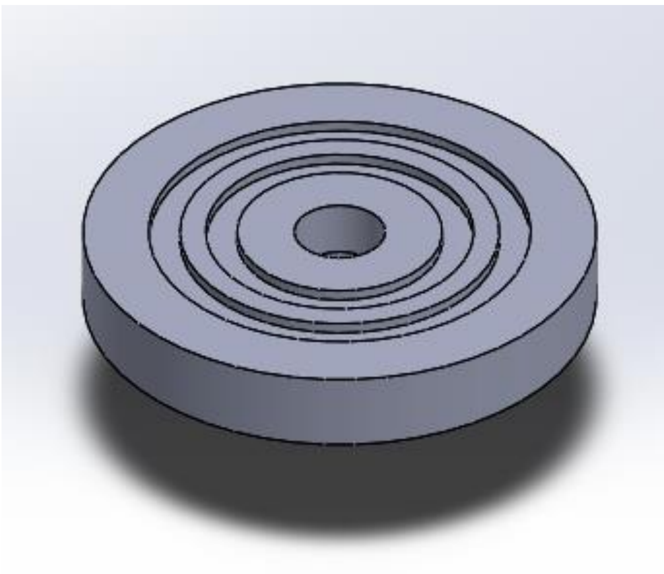

Figure 3-5: Chuck that used to hold substrate

Table 3-1 shows the list of parts that purchased or fabricated. All fabricated parts will used material and equipment that available in workshop School of Mechanical. The detail of purchased will be showed in Table 3-3.

Table 3- 1: List of parts to be purchased or fabricated and material used.

Part	**Material**	**Purchased or fabricated**
Spin bowl	Aluminium	Purchased
Casing (a) Top, bottom and side plates (b) Front and back plates	(a) Mild steel (b) Polypropylene (PP) hollow plate	(a) Fabricated (b) Purchased
Power unit (a) motor (b) base plate (c) side holder plates (d) top holder plate (e) side supporter plates (f) top supporter plate (g) coupling (h) motor shaft (i) pulley (j) bearing	(b), (d) and (e) Mild steel (c) and (f) Aluminium (h) Polylactic acid (PLA)	(b), (c), (d), (e), (f) and (h) Fabricated (a), (g), (i) and (j) Purchased
Vacuum unit (a) side and top holder plates (b) side supporter plates (c) top supporter plate (d) rotary union (e) vacuum connector (f) bearing (g) base shaft (h) top shaft	(a) and (b) mild steel (c) aluminium (g) and (h) Polylactic acid (PLA)	(a), (b), (c), (g) and (h) Fabricate (d), (e), and (f) Purchased