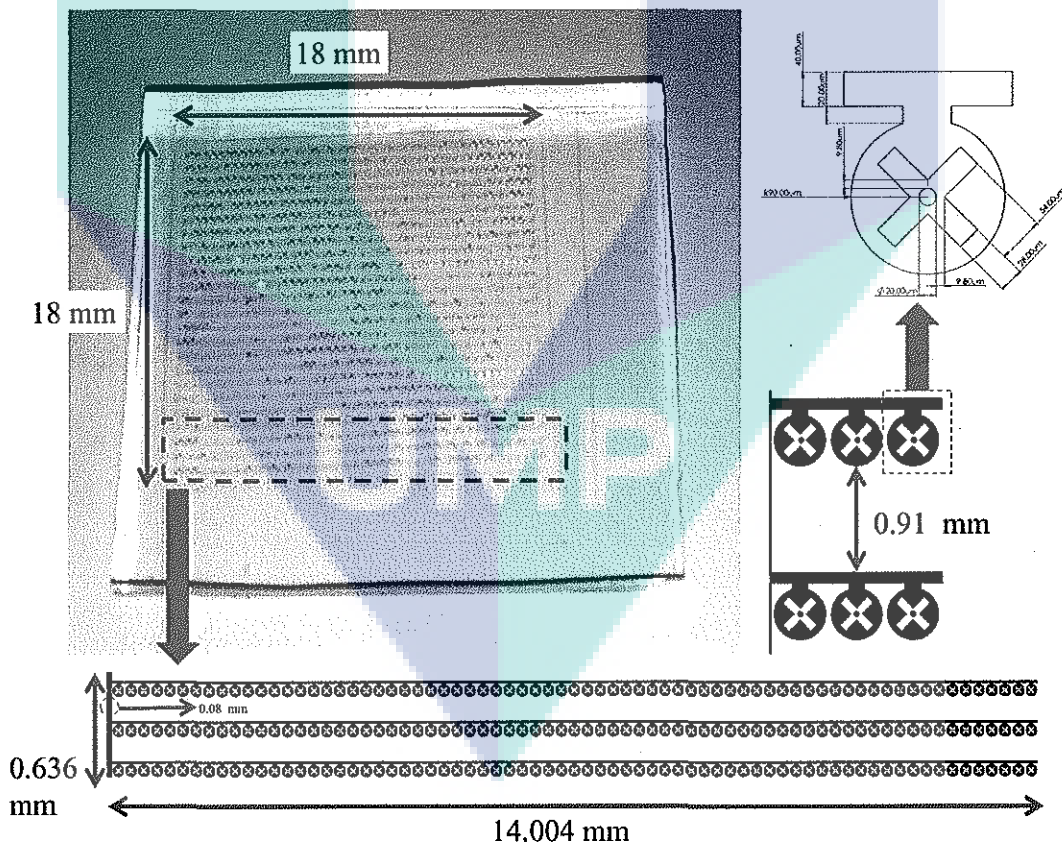
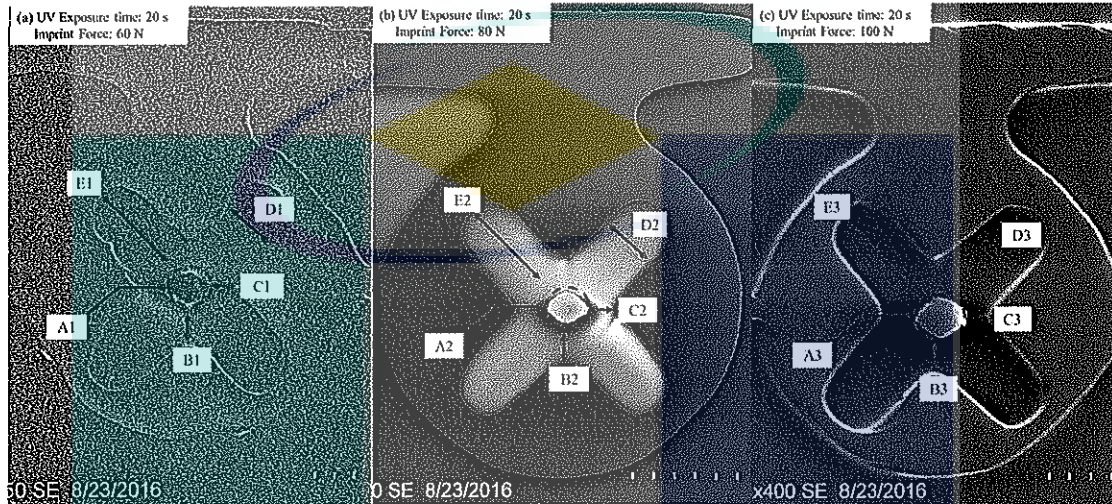


BUKU PROFIL PENYELIDIKAN SKIM GERAN PENYELIDIKAN  
 FUNDAMENTAL (FRGS) FASA 1/2013 DAN FASA 2/2013



# PROCESS DEVELOPMENT OF THE DEVICE USING IN-HOUSE PLATE-TO-PLATE TOOL WITH NANOIMPRINT LITHOGRAPHY TECHNIQUE FOR BIOCHIP APPLICATION

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## ABSTRACT (120 words)

Biochip is a promising device with capabilities of performing sorting, trapping and screening a large number of biological samples in a short time. Fabrication of biochip pattern process leads to an opening study towards the development of a working biochip. The traditional photolithography process have a limitation in achieving high throughput for biochip pattern fabrication. In this research, the fabrication process of biochip pattern was developed and the imprint parameter for biochip pattern using an in-house assembled plate-to-plate tool was investigated. The biochip patterns are prepared from existing projection lithography to create the mold. Using soft lithography technique, the biochip pattern was replicated invertly in the PDMS mold.

## 1. INTRODUCTION

The biochip is a platform of miniaturized microarrays arranged on a solid substrate that permits multiple tests to be performed at a time to achieve quick to respond (Samsuri et al., 2011). According to Chaithanya et al. (2011), the overall size of a biochip is not larger than a fingernail size. Cheng et al. (2001) stated that the biochip can perform thousands of biological reactions, such as sorting, trapping, and screening large numbers of biological samples of a variety of purposes, from disease diagnosis to detection of bioterrorism agents in a short time.

Nanoimprint lithography (NIL) was introduced by Prof. S.Y.Chou and his team in developing a low cost and high throughput manufacturing method (Chou et al., 2007) Nanoimprint lithography is a method of fabricating micro and nanoscale patterns. In the NIL process, it creates patterns of mechanical deformation of imprint resist and subsequent operations. The imprint resist is a monomer or polymer

formulation that can be cured by heat or UV light during the imprinting (Kooy et al., 2012). Nanoimprint lithography (NIL) is a promising method of high resolution, high throughput, and low-cost patterning technique. The NIL process consists a mechanical replication process where surface reliefs from the template were embossed with a thin layer on the substrate (Viheriälä et al., 2010).

Poly (dimethylsiloxane) (PDMS) is a promising material for many applications nowadays because of its outstanding properties. PDMS has been widely used to fabricate biomedical devices, Micro-Electro-Mechanical Systems (MEMS), micro fluidic dices, micro-stamps by molding techniques. In addition, Bubendorfer et al. (2007) stated PDMS offers advantages regarding ease of fabrication, biocompatibility, chemical resistance and flexibility in the application.

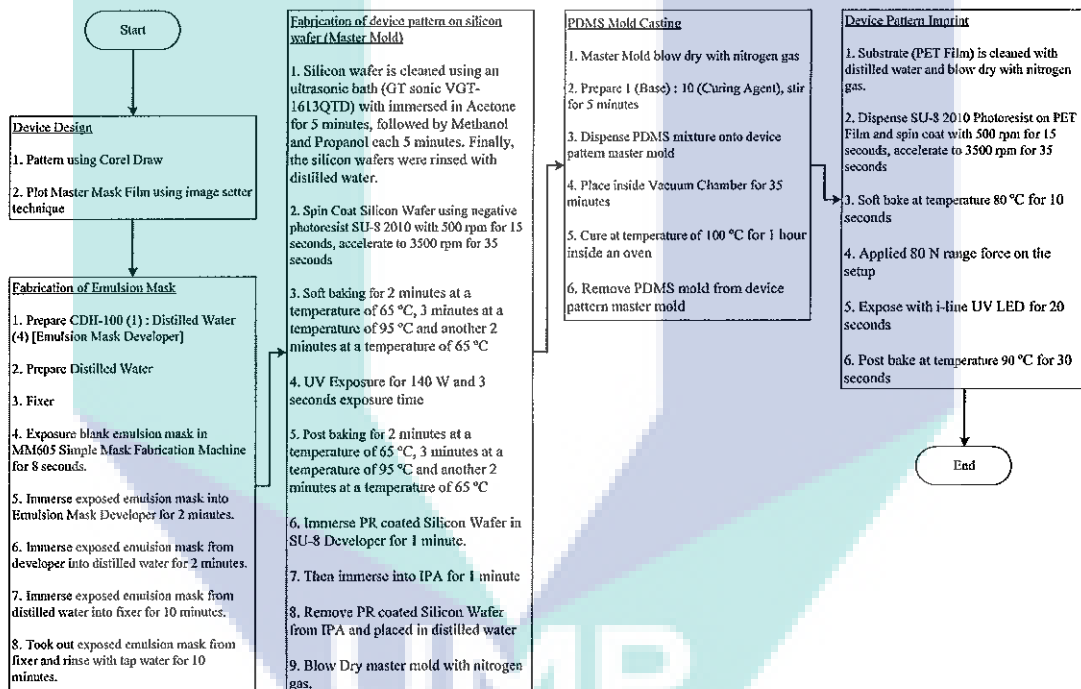
Generally, NIL process has been explored by researchers as a highly promising high-throughput alternative to the conventional lithography. Precise surface patterning with micro and nanoscale resolution has great potential in biological applications such as biochip Vigneswaran et al. (2014). One of the areas includes investigation of the imprint capability using UV-NIL technique since UV-NIL does not require high temperature and high pressure during the process. In addition, Haisma et al. (1996) also stated no additional chemistry is required for patterning in exposing and developing. Compared to thermal NIL, the processing time in UV-NIL is significantly faster as it does not require temperature control like thermal NIL. Table 1.1 shows a brief summary of the nanoimprint lithography techniques.

Table 1.1 A tabulated comparison for Thermal NIL, UV-NIL, SSIL and SFIL

<b>Nanoimprint Lithography Technique</b>	<b>Resist Curing Element</b>	<b>Temperature require</b>	<b>Pressure require</b>	<b>Imprint Productivity</b>	<b>Process duration</b>
Thermal NIL	Heat	High	High	Low production	Slow
UV-NIL	UV	Room	Low	Low production	Fast
SSIL	Heat	High	High	Mass production	Slow
SFIL	UV	Room	Low	Mass production	Fast

Although many works had been done by previous researchers on biochip fabrication, nevertheless, the investigation of biochip fabrication pattern using conventional lithography technique is still an ongoing topic. Furthermore, the detailed elaborations on the fabrication process parameters were not been highlighted in the literature findings. Therefore, this provides ample space for investigation of patterning capability using photolithography techniques to create the mold. Followed by soft lithography to create a transparent mold and finally using UV-NIL to investigate the imprint capability.

## 2. RESEARCH METHODOLOGY



## 3. LITERATURE REVIEW

Lithography was the initial fundamentally new printing technology following the invention of relief printing back in the 15th century. Alois Senefelder of Germany invented lithography process in 1796. His invention made a breakthrough in England and the United States (Senefelder, 2013). Based on research by Zaouk et al. (2006), the word “lithography” originated from Greek; (lithos) addressed as “stone” while (gráphein) meant “write”. This leads to the meaning of writing on stones. In most

microfabrication, the stone is referred as a substrate while patterns are written on a substrate using a light sensitive polymer known as photoresist.

According to Wagner (2010), photolithography is one of the continuous efforts to improve the resolution in the existing lithography system present in the semiconductor industry. Photolithography appears to be the key driver for scaling down large scale of the pattern by using an optical lens or reducing the wavelength of the light used. Be that as it may, Garner (2013) pointed out the fabrication technique for biochip is applicable with photolithography as Rao et al. (2012) stated that the two-dimensional grid of biosensors is one of the core components in the biochip platform. Hence, photolithography is recommended in the fabrication process of the biochip. The sensor pattern from the biochip requires a mask and light acted as the medium to transfer the pattern towards a flat substrate, such as silicon wafer in the initial fabrication procedure.

The general sequence steps of a typical photolithography processing as proposed by (Mack, 2008) are as follows; (i) substrate preparation; (ii) photoresist spin coat; (iii) prebake; (iv) UV exposure; (v) post-exposure bake; (vi) development

### **3.1 Substrate Preparation**

Donose et al. (2006) stated that the development of high performance devices in the microelectronics industries requires a standard. Based on Kern (1990) review of silicon wafer technology, the presence of organic contaminants will lead poor adhesion for photoresist deposition. In fact, there are three forms of contaminants that potentially occur on the surface of the substrate; (i) contaminant films, (ii) discrete particles, and (iii) smoke particles. Contamination films are caused by inorganic compounds that might physically attach or chemically bonded to the surface of the wafer. Discrete particles and smoke particles are condensed organic vapours from lubricants, solvent residues, fingerprints and components from storage containers.

The RCA cleaning method was developed by Kern (1970) at Remote Chemical Analysis (RCA) Laboratories. This method has been adopted as a standard wafer cleaning procedure in the silicon semiconductor technology. The RCA cleaning method decontaminates the wafer surface from oxidized surface hydrophobic to oxidised surface hydrophilic. Franssila (2010) provided evidence that the hydrophilic surface has

the study by Guo et al. (2012), the typical spin speed for this step ranges from 2000 to 4000 RPM.

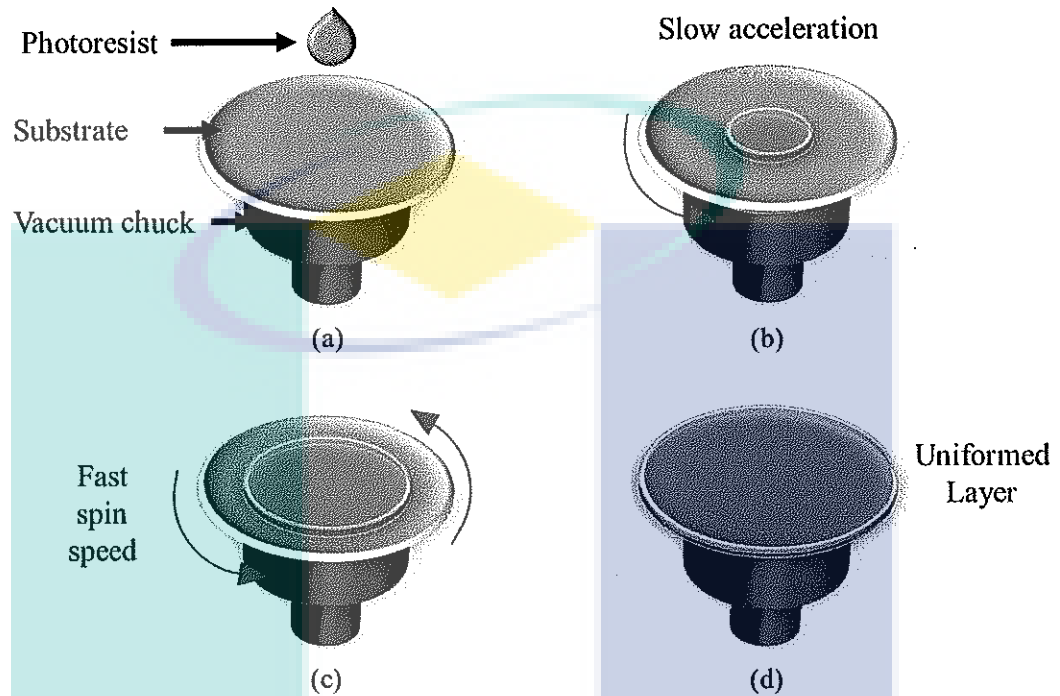


Figure 1.2: Photoresist spin coating process: (a) a controlled volume of photoresist dispensed on the substrate surface, (b) slow acceleration spread the photoresist across the substrate, (c) fast spin to create a uniform layer, (d) A thin layer was produced  
Source: Mack (2008)

Even though there are many parameters which affect the thickness and the uniformity of the photoresist film, Daughton et al. (1982) stated that dispense volume, dispense speed, and spin acceleration do not have much effect towards on the final average photoresist film thickness. However, Yang and Chang (2006) concurred and claimed that the dispensation speed is the most significant factor to attain a better uniformity of final photoresist film thickness. Nevertheless, based on Pham et al. (2002) and Mack (2008) studies, the photoresist solution viscosity and spinning speed strongly influence layer forming. Figure 1.3 shows the relationship between photoresist viscosity, final spin speed, and the final photoresist thickness.

contact angles (CAs)  $< 90^\circ$ , while the hydrophobic surface has CAs  $> 90^\circ$ . Figure 1.1 shows the behaviour of water on both hydrophilic and hydrophobic surfaces.

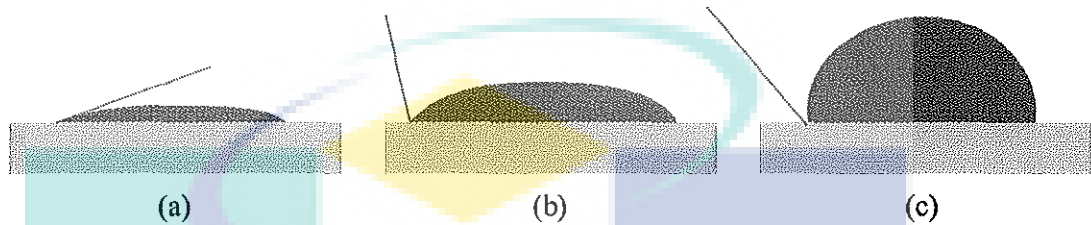


Figure 1.1: Contact angles of water droplets on a wafer: (a) hydrophilic surface,  $20^\circ$ , (b) hydrophobic surface,  $95^\circ$  and (c) super-hydrophobic surface,  $150^\circ$

However, according to Donose et al. (2006), the continuous washings of wafers with acetone, ethanol and deionized (DI) water were capable of reducing the CAs to  $30^\circ$  -  $20^\circ$ . In addition to that, usage of sonicated vessel can reduce the CAs to almost  $10^\circ$ . Thus, this became an alternative to the RCA cleaning process.

### 3.2 Photoresist Spin Coating

The photoresist spin coating is a process which deposits a thin layer of photoresist on the substrate surface. The thin layer of photoresist is uniformly deposited in a pre-determined/ required thickness. The process is carried out by placing a silicon wafer on a spindle using a vacuum chuck to hold it. The determined speed produces desired thin film thickness. Sahu et al. (2009) pointed that the centrifugal force produced by the turntable drives the photoresist radial outward. Figure 1.2 shows the photoresist spin coating process.

Generally, the photoresist is dispensed from a dropper onto the substrate surface, as shown in Figure 1.2 (a). According to Pham et al. (2002), slow acceleration and spin speed gives sufficient time for the photoresist to flow and spread across the substrate surface in the first step. This process is in Figure 1.2 (b). This is followed by fast spin speed to create a uniform layer as shown Figure 1.2 (c). Finally, the uniform layer resulted in the formation of a thin film on the substrate as shown in Figure 1.2 (d). In

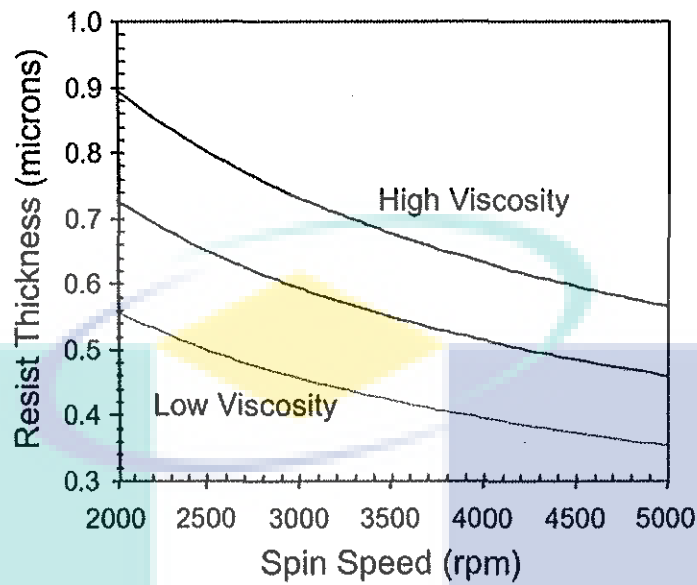


Figure 1.3: Photoresist spin speed curve for resist viscosity

Source: Mack (2008)

### 3.3 Photoresist

In order to understand the photolithography process, it is important to identify the core elements of the photoresist. According to Martinez et al. (2010), the primary components of the photoresist are; (i) polymer (base resin), (ii) sensitizer, and (iii) casting solvent. The structure of the polymer will be changed during electromagnetic radiation exposure. The chemical reactions in the polymeric phase are controlled by the sensitizers. The formation of thin film depends on the casting solvent in spin coat applications. Generally, the photoresist can be classified into two groups; (i) positive photoresist and (ii) negative photoresist. During exposure for positive photoresist, the polymer is weakened by rupture or scission of the main side of the polymer chain.

Thus, the exposed photoresist becomes more soluble during the development process. On the other hand, the polymer of negative photoresist strengthens when exposed. This results in random cross-linkage formation on the main side of the polymer chain. Thus, the exposed photoresist becomes less soluble. In addition, Shaw et al. (1997) stated that the exposure of the photoresist towards the UV light (range 200-



300 nm) would result in the photoresist to form cross-linkage. Figure 1.4 shows chain scission (positive photoresists) and cross-linking (negative photoresists).

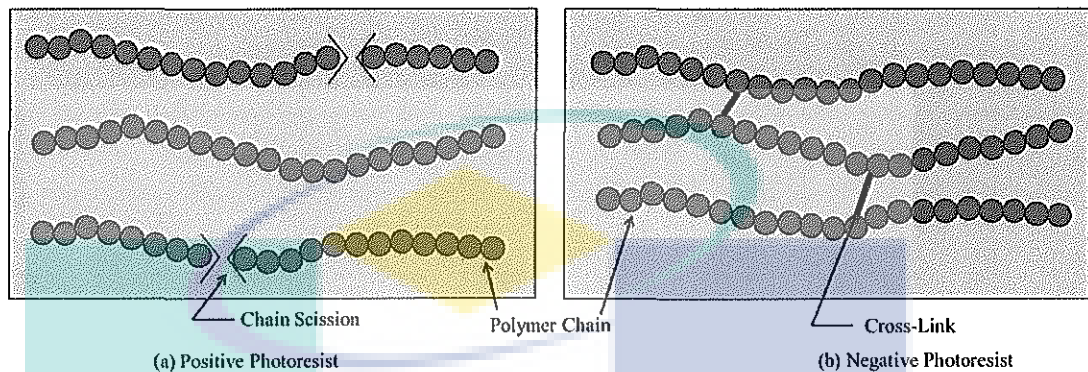


Figure 1.4: Polymer reaction during the exposure process: (a) Polymer Chain scission on the positive photoresist, (b) Polymer cross-link on the negative photoresist

Source: Martinez et al. (2010)

Moreover, Shin-Etsu (2013) stated both positive and negative photoresist are still being used in MEMs industry today. Positive photoresist has higher resolution capabilities while negative photoresist has a faster photo speed and wider process latitude. Both positive and negative photoresist have its own advantages and disadvantages towards the application. Mack and Connors (1992), reviewed the difference between positive and negative photoresist showing that both photoresists are fundamentally different on two levels.

### 3.4 Prebake

After photoresist spin coating, Mack (2008) stated the thin layer of photoresist will contain 20 % to 40 % of the solvent by weight. The main purpose for prebake or also known as soft bake is to reduce the excess solvent content and improve both the adhesion between photoresist uniformly according to (Dai et al., 2005).

Moreover, insufficient prebake causes the photoresist to become sticky; whereas, over-bake reduces the adhesion strength between the photoresist and substrate. In order to retain the internal stresses of photoresist at a minimum stage, Liu et al. (2001) claimed that the initial bake stage should be done before prebake. The common temperature in initial bake is 65 °C while prebake is in 95 °C. However, Anhoj et al.

(2006) concluded prebake with the temperature at 65 °C provides crack free structures in the photoresist. Furthermore, the prebake condition varies on the type of photoresist and solvent used. Therefore, it is important to identify the optimum parameters for prebake process for a perfect structure in the photoresist.

The common equipment used in prebake are the conventional oven baking method and hotplate baking methods. The conventional oven baking method was popular back in the 1970s and the early 1980s. In turn, hotplate has now become the baking alternative. According to Martinez et al. (2010), the advantage of hotplate over the conventional oven is that more parameters to control baking process and faster baking.

### 3.5 UV Exposure

After prebake, the coated substrate is transferred to an exposure system. The basic principle of an exposure system is to change the solubility of the photoresist in the developer when exposed to UV light. The UV exposure system setup aligns the patterned photomask with the coated substrate. A UV lamp then projects illumination towards the setup. The resist on the coated substrate undergoes chemical changes after its exposure to the UV light. Thus, this allows the pattern from the photomask to transfer onto the resist in the form of a latent image. According to Yang and Wang (2005), the UV light range is usually from (320 nm to 420 nm) commonly used in exposure. In addition, Yang et al. (2013) stated the lines at several distinct frequencies; (i) deep UV light (254 nm), (ii) i-line (365 nm), (iii) h-line (405nm) and (iv) g-line (436 nm). However, i-line source usually recommended for SU-8 photoresist microstructure.

Based on Martinez et al. (2010) perspective, the UV incident energy (J/cm<sup>2</sup>) or dosage can be calculated by multiplying the UV light intensity (in W/cm<sup>2</sup>) and UV exposure time (in seconds) as shown in Eq. (1.1). Therefore, thinner photoresist layer requires a lower UV dosage to ensure a good curing of the photoresist.

$$UV_{dosage} = UV_{intensity} * UV_{exposure}$$

Generally, Dong and Brent (2004) stated there are three different types photolithography in the exposure system: (i) contact lithography, (ii) proximity lithography, (iii) projection lithography as shown in Figure 1.5. Contact lithography is a technique where the photomask is directly in contact with the substrate. This exposure technique allows high-resolution microstructure to be produced. However, due to frequent surface contact, defects on the mask pattern occur, which results in low yield through this process. On the other hand, proximity lithography reduces the mask damage by keeping a distance around  $20\ \mu\text{m}$  from the substrate. Unfortunately, the limitation of resolution increases as the distance increases for proximity lithography.

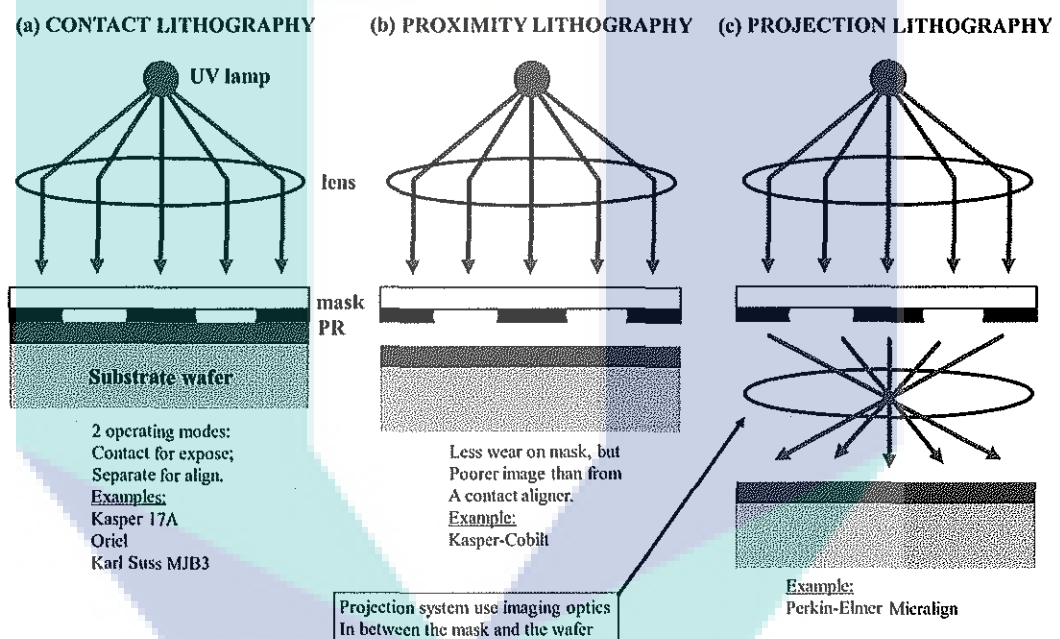


Figure 1.5: Types of photolithography in exposure system: (a) Contact lithography, (b) Proximity lithography, (c) Projection lithography

Source: Martinez et al. (2010)

Projection lithography was introduced to replace both contact and proximity lithography to resolve these problems. Matsuyama et al. (2006) reviewed that first development of projection lens was carried out by Nikon in 1962. Hsieh et al. (2014) stated that projection lithography utilizes optical imaging projection by using a demagnification factor of 1:5 and 1:10. This method increases the durability of the

photomask. Lastly, by using collimator lenses, the phenomena of diffraction in projection lithography were minimized.

### 3.6 Post-Exposure Bake

After UV exposure, the post-exposure bake (PEB) strengthens the hardness of the thin film on the substrate. According to Madou (2011), the improved hardness on thin film increases the resistance of the thin film in the development process. Apart from strengthening the thin film, Walker (1975) stated the significance of PEB in reducing the residual effects of standing waves and in improving the line width control. The standing wave effect occurs when the light projects towards a reflective photoresist on the substrate as shown in Figure 1.6. Hence, the incoming and reflected light creates an interference that causes high and low light intensities at different depths in the photoresist. Therefore, PEB requires higher temperature from (100 °C to 130 °C) in order to reduce the standing wave effect.

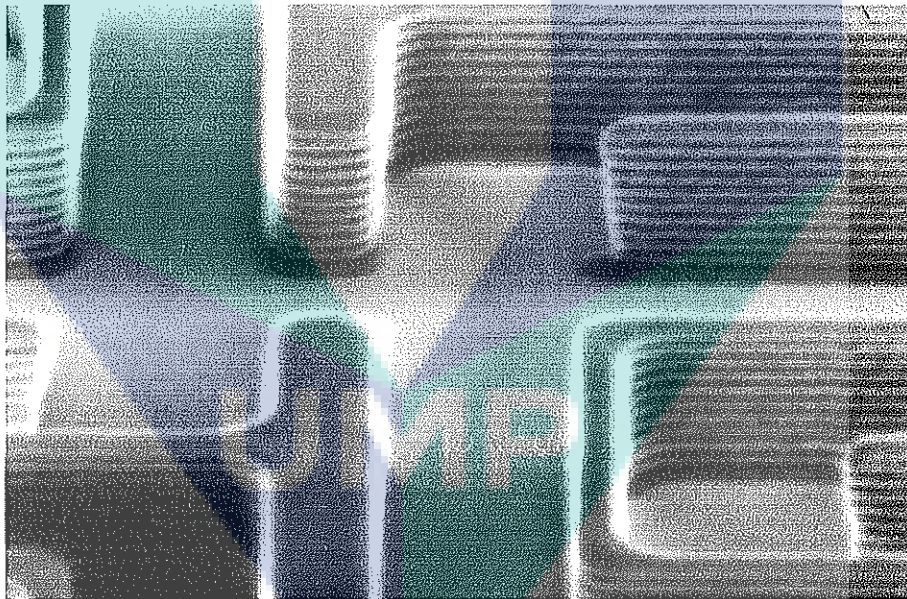


Figure 1.6: Image of standing waves effects on the sidewalls of resist features  
Source: Mack (2008)

### 3.7 Development

The development process is done after PEB to transform the latent image in the photoresist into a microstructure. The development process is also known as subtractive

(etching) according to (Mack, 2008). Generally, etching is performed using wet chemicals, therefore the term “wet etching” is classified. Depending on the photoresist type, the selected photoresist will be etched during the development process. Specifically for positive photoresist, the polymer in the exposed region becomes weak, resulting in a soluble state during the development process. However, the polymer in the unexposed region for negative photoresist becomes strengthened. Therefore the unexposed region will be etched in the development process as shown in Figure 1.7 (Madou, 2011)

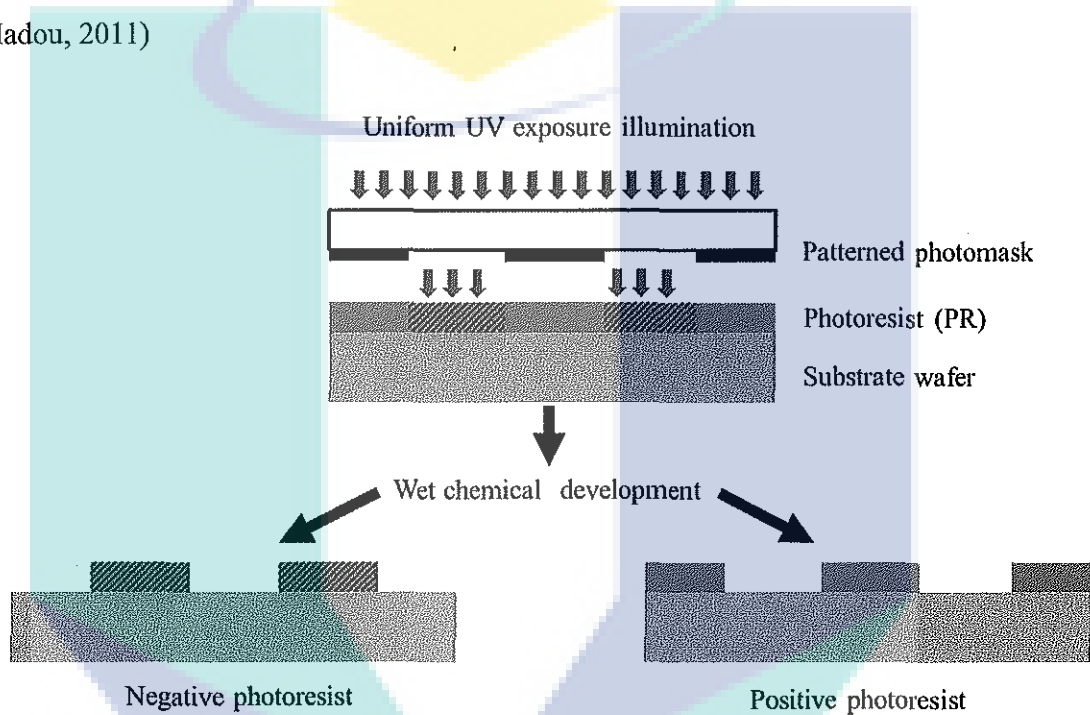


Figure 1.7: Wet etching difference between the negative photoresist and the positive photoresist. Source: Madou (2011)

### 3.8 Soft Lithography

When compared to the photolithography, Weibel et al. (2007) stated soft lithography technique is simple and suitable for creating micro or nanoscale structures in soft materials such as poly-dimethylsiloxane (PDMS). In addition, soft lithography is proven useful in terms of the capability to produce pattern replication from the inverse pattern of a master mold.

Based on Xia and Whitesides (1998), the key element of soft lithography as shown in Figure 1.8 is the photoresist (structure) on the surface of the master mold. The PDMS

is dispensed over the surface of the master mold. After that, the PDMS is cured and peeled off.

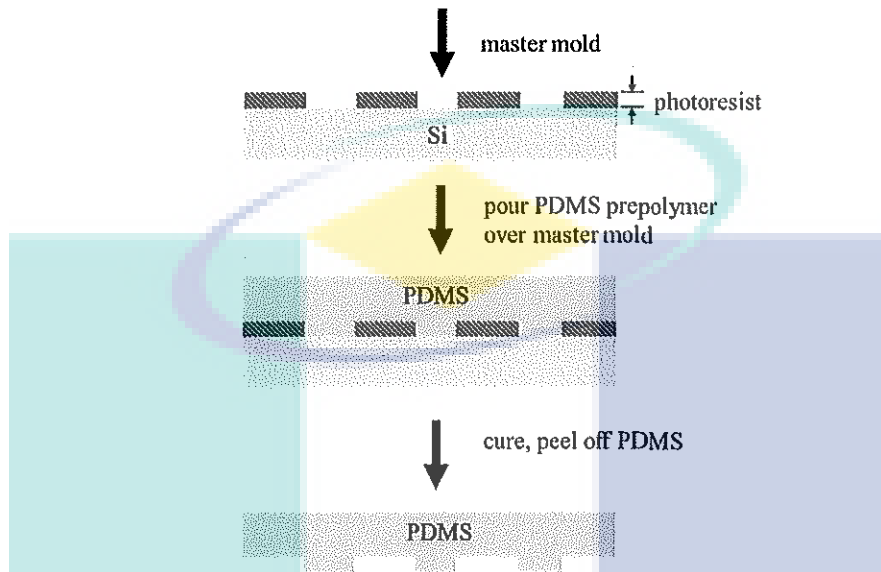


Figure 1.8: Schematic illustration of the procedure for casting PDMS replicas from a master mold with the structure on the silicon wafer surface

Source: Xia and Whitesides (1998)

In summary, a compilation of the comparison between photolithography and soft lithography is shown in Table 1.2. Source from (Krogh & Asberg, 2003), (Li et al., 2004), (Weibel et al., 2007) and (Shin et al., 2012)

Table 1.2: A tabulated comparison between Soft Lithography and conventional optical lithography

	<b>Photolithography</b>	<b>Soft lithography</b>
Definition of process	Rigid photo mask (patterned Cr supported on a quartz plate)	Elastometric stamp or mold (a PDMS block, patterned with relief features)
Materials that can be patterned directly	Photoresists (polymers with photosensitive additives)	SiO <sub>2</sub> (Silicon dioxide), Si <sub>3</sub> N <sub>4</sub> , (Silicon Nitride), metals, Photoresist, or wax
Surfaces and structures that can be patterned	Planar surfaces 2-D structures	Both planar and nonplanar Both 2-D and 3-D structures
Current resolution limits	250 nm (projection) 100 nm (laboratory)	30 nm 6 nm

### 3.9 Overview of Nanoimprint Lithography.

Nanoimprint Lithography process was presented by Chou et al. (1996) in 1995. Nanoimprint lithography (NIL) is a type of nanofabrication process which produces micro- or nanoscale structure or patterns by mechanically deforming the resist on the substrate through imprint process. According to Torres (2012), a basic NIL process consists of three components: (i) a mold with required feature size and pattern, (ii) material to be printed (resist), (iii) and imprint mechanism.

The resist can be in the form of thermal plastic Chou et al. (1995) or curable polymer (Ruchhoeft et al., 1999) using UV light exposure. The thermal plastic heated above its glass transition temperature during imprint where the resist becomes viscous liquid and the mold is pressed into the resist using force as shown in Figure 1.9. On the other hand, the curable polymer, often in a liquid thin film on the substrate and exposed to UV light radiation. Based on Kooy et al. (2014), the imprint mechanism for NIL can be carried out with several types of machines: (i) roll-to-roll, (ii) roll-to-plate, (iii) plate-to-plate. NIL process has a great advantage as it can be operated at lower cost and higher throughput compared to conventional lithography technique (Mohamed et al., 2006) and (Guo, 2007). In addition, NIL process can achieve resolution beyond the limitations set by light diffraction or beam scattering that encounter by previous conventional techniques (Alkaisi et al., 2010).

The logo for UMP (Universiti Malaysia Perlis) is a large, stylized letter 'U' composed of several overlapping triangles in shades of blue, teal, and yellow. The letters 'UMP' are printed in a bold, white, sans-serif font across the center of the 'U' shape.

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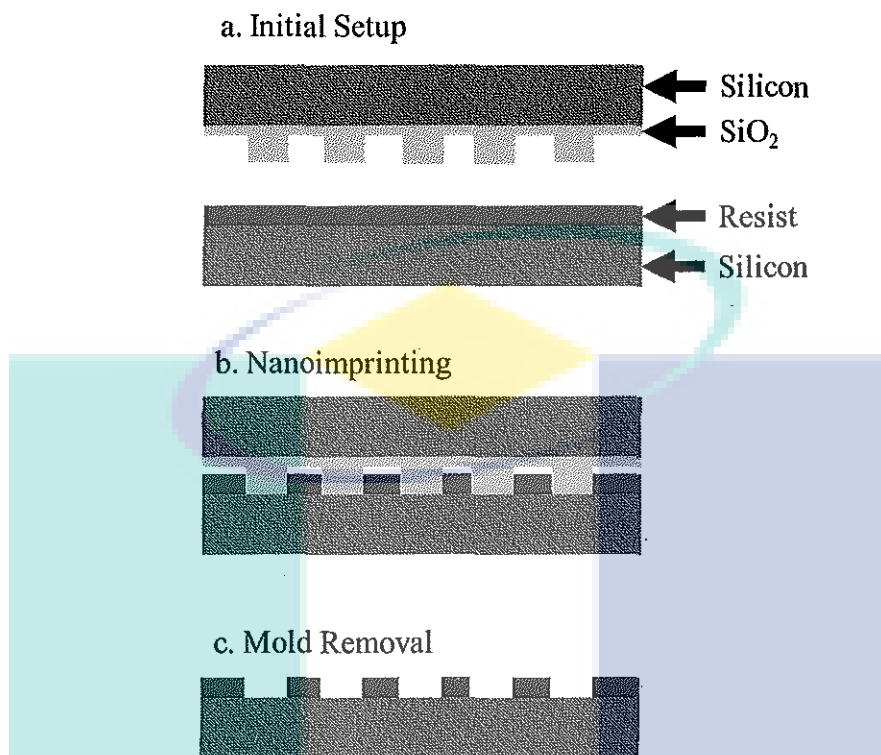


Figure 1.9 Schematic of nanoimprint lithography process

Source: Chou et al. (1995)

Based on the review from Vigneswaran et al. (2014), imprint techniques can be classified to thermoplastic nanoimprint lithography (T-NIL), UV-NIL, step and flash imprint lithography (SFIL) and step and stamp imprint lithography (SSIL). NIL technique is also applied in biochip fabrication (Choi et al., 2009).

### 3.10 Thermal Nanoimprint Lithography

Thermal Nanoimprint Lithography or known as hot embossing was the first nanoimprint lithography developed by (Chou et al., 1995). According to Hirai et al. (2003), the process of thermal NIL starts by spin coating a thin layer of resist on the substrate. A mold consisted of pattern structure is brought into contact with the surface of the thin film with an amount of pressure. The polymer of the resist is heated up above the glass transition temperature. The patterned mold is pressed into the softened polymer thin film. The setup is then left for cooling down. After cooling down, the mold and the polymer thin film are separated where the imprinted patterns are formed



on the substrate. Figure 1.10 shows the typical process in thermal nanoimprint lithography.

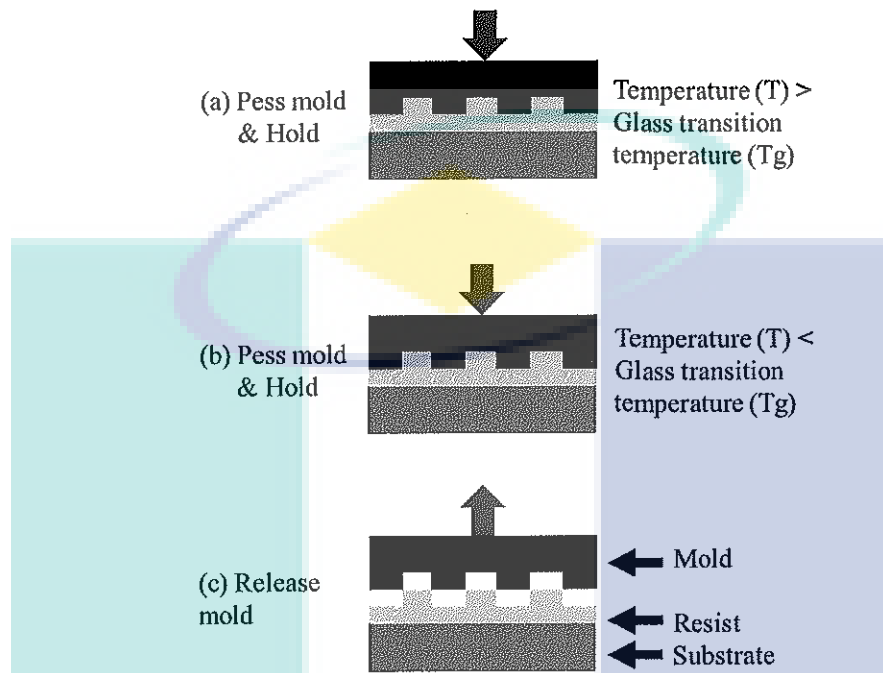


Figure 1.10: A typical process in thermal nanoimprint lithography: (a) heating and pressing, (b) cooling, and (c) releasing

Source: Hirai et al. (2003)

However, Jung et al. (2004) stated the high temperature and high-pressure requirement as a limitation, during the operation of the thermal NIL process. The potential of high temperature and high pressure results in damaging the imprinted substrate and the mold. Thus, Park et al. (2009) point out the temperature control parameter of thermal NIL is the most important. The mismatch of temperature control will result in thermal stress, which occurs during the cooling process. This results in adhesion of the resist and friction occurring at the sidewall of the mold and resist when demolding.

### 3.11 UV Nanoimprint Lithography

UV Nanoimprint Lithography (UV-NIL) is another technique developed by (Haisha et al., 1996) from Philips Research Laboratories. The resist used in UV-NIL is UV

curable when contacted with UV light radiance. According to Haisha et al. (1996), the resist used in UV-NIL should have a high curing rate, sufficiently low viscosity and good adhesion on the substrate after curing. The typical process of UV-NIL as shown in Figure 1.11: (a) a patterned mold and substrate are prepared, (b) resist is dispensed on the substrate surface, (c) contact between mold and the coated substrate are applied and exposed to the UV light, (d) pattern from the mold is imprinted on the coated substrate and (e) an imprinted structure is obtained.

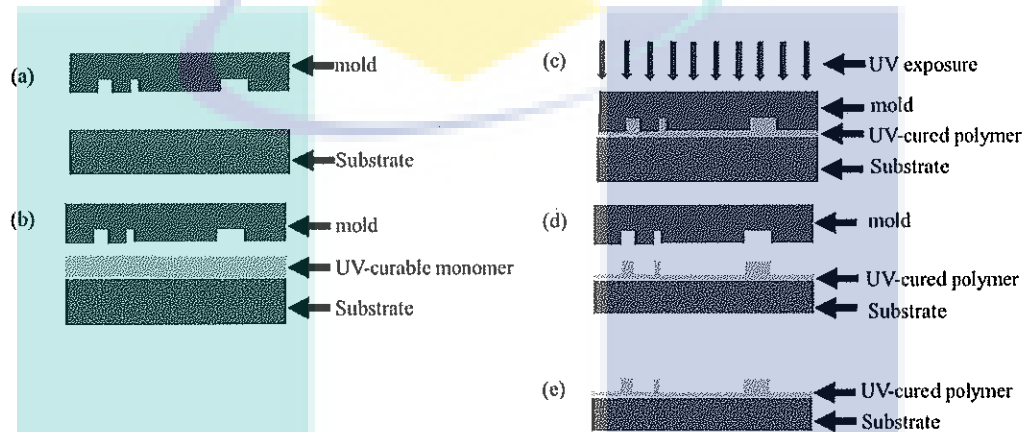


Figure 1.11: UV-NIL process: (a) patterned mold and substrate prepared, (b) resist is dispensed on the substrate surface, (c) contact and UV exposed on the resist, (d) lift off and (e) pattern is imprinted on the substrate surface

Source: Haisha et al. (1996)

The advantages of UV-NIL are that the operation can be performed at room temperature as it does not require high temperature. In addition, Haisha et al. (1996) stated a less contact force is required in UV-NIL due to the low viscosity of the resist polymer.

### 3.12 Step and Stamp Imprint Lithography (SSIL)

Step and Stamp Imprint Lithography is an alternative technique developed by (Haatainen et al., 2000). This technique aimed to perform imprint on a larger surface area. Figure 1.12 shows the process of SSIL. First, the temperature of the mold increased above the glass transition of the temperature of the resist. The mold is then in contact towards the substrate surface. The mold kept in contact with the substrate in a determined time to allow the pattern embossed from the mold. The setup then allowed

to cool down and lifted up from the substrate surface. After that, the mold moved to the next site and the entire process is repeated until the entire surface is completely imprinted. The resist used in SSIL is a thermoplastic polymer.

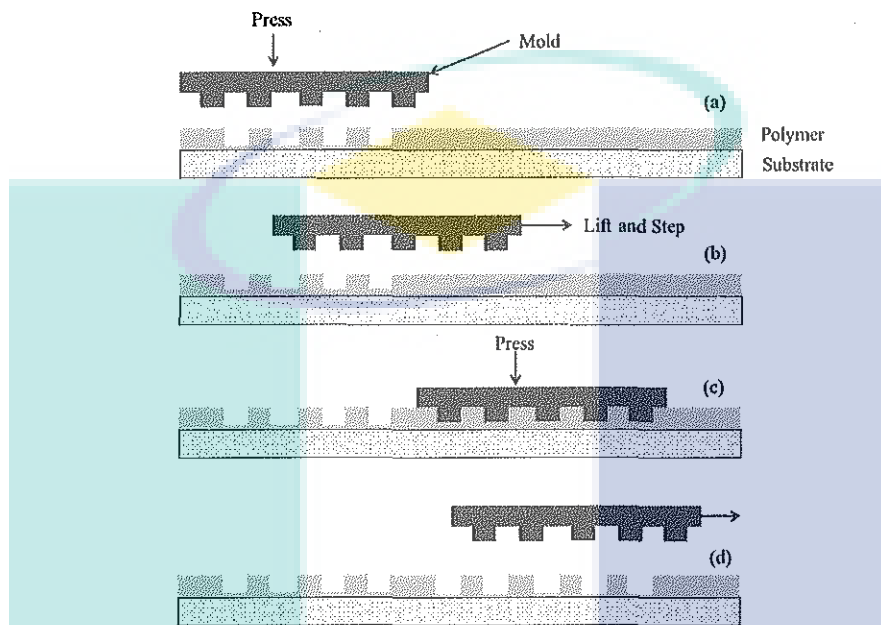


Figure 1.12 SSIL Process: (a) Mold is heated up above  $T_g$  and in contact with the polymer, (b) after cooling down, the mold is lifted up and move to next position, (c) the mold repeat the process from (a) to (b), (d) the mold is lifted up and move on

Source: Haatainen et al. (2000)

### 3.13 Step and Flash Imprint Lithography (SFIL)

Step and Flash Imprint Lithography (SFIL) is a technique derived from UV-NIL. This technique developed by Wilson and Sreenivasan in 1999 (Colburn et al., 1999). According to Resnick et al. (2005), SFIL is introduced to resolve high expenditure in printing sub- 100 nm features. The SFIL process is illustrated in Figure 1.13. A transparent mold with the pattern and the substrate are aligned. The transfer layer is spin coated on the substrate surface. The etch barrier is dispensed on the surface of the transfer layer. After that, by applying force the mold is lowered down until made contact on the substrate surface. The setup is exposed to UV light radiation through the backside of the mold. The etch barrier is cured by UV exposure and turned into a cross-linked polymer film. The mold is lifted up leaving an imprinted pattern on the surface

substrate. The residual etch barrier (base layer) is etched away with a short halogen plasma etch, after which the pattern is transferred into the transfer layer with an anisotropic oxygen reactive ion etch to amplify the aspect ratio of the imprinted image.

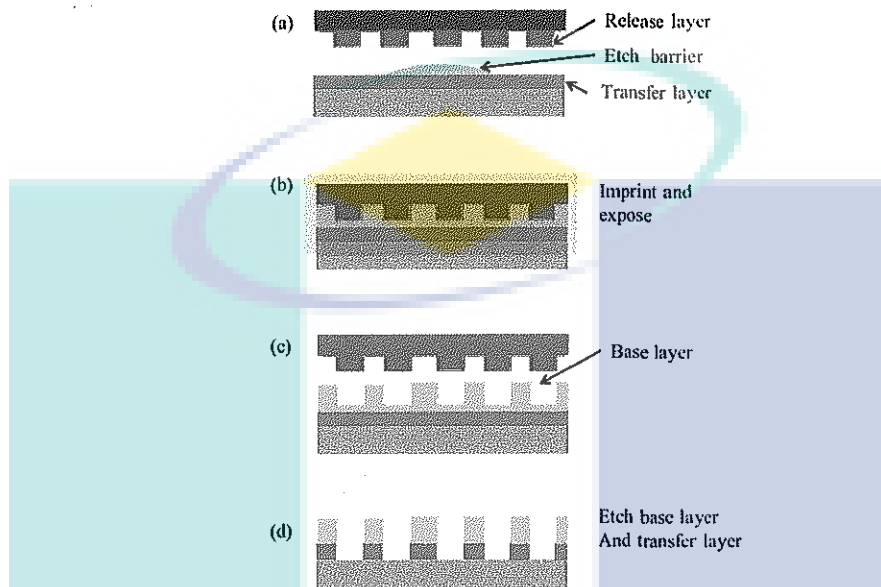


Figure 1.13: SFIL Process: (a) transfer layer is spin coated on the substrate surface, etch barrier is dispensed on top of transfer layer, (b) gap between release layer and transfer layer are closed, trapping etch barrier and exposed to UV light, (c) the mold is lifted off while imprinted structure formed on the base layer, (d) residual etch barrier is etched using plasma etch and transfer layer is etched using oxygen reactive ion etch

Source: Resnick et al. (2005)

Similar to UV-NIL, SFIL operates at room temperature and required less imprint force compared to thermal NIL and SSIL. In addition, Colburn et al. (1999) stated that the required pressure applied in SFIL is only up to 15 psi, while in SSIL required temperature is up to 180 °C and longer processing time.

#### 4. FINDINGS

The DED between biochip pattern mold and PDMS mold are less compared to biochip pattern mold fabrication in the photolithography process. Critical dimension in the biochip pattern was maintained in the imprint process. However, the higher imprint force will cause an overflow of the resist on the substrate, resulting unsatisfied pattern structure. The proposed parameters for imprinting biochip patterns using in-house plate-to-plate tool are 80 N range and 20 seconds of UV exposure.

#### 5. CONCLUSION

This research is successfully achieving all the listed objectives. In the present study, the device pattern fabrication process using commercially available polymer resist has been presented. By using the proposed parameters in photolithography, the device patterns are developed on the silicon wafer substrate. In order to obtain precise pattern during photolithography, optical proximity correction are recommended. Besides that, several process parameters, such as UV exposure and post bake exposure were tested. Moreover, the relationship between the width size and percentage difference had been determined. Based on the results obtained, a log graph was plotted.

To characterize the device pattern imprint process using the in-house plate-to-plate tool, a PDMS mold was cast using soft lithography technique with (Sylgard 184, Dow Corning) as the material. The imprint setup is demonstrated by tightening the nuts to create a contact force. The contact forces are monitored in real time from the computer via A201 force sensors.

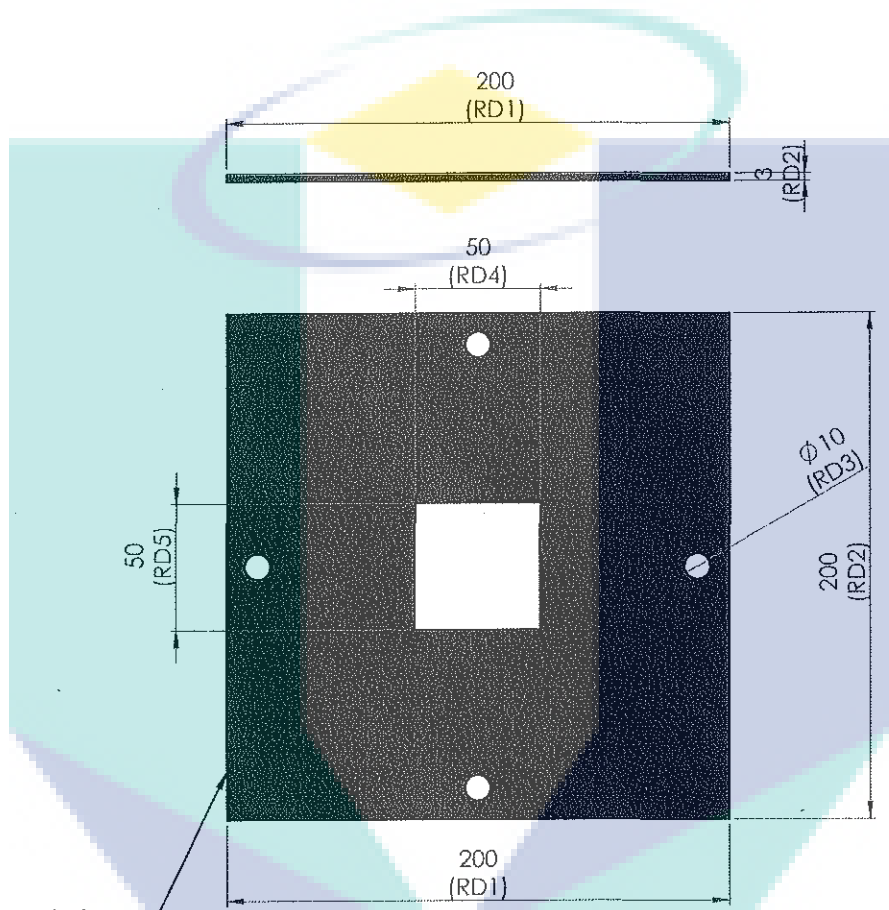
#### ACHIEVEMENT

i) Name of articles/ manuscripts/ books published

S. Nursyahirah A. Latfi and F. Samsuri "Biochip Development for Biological Cells Manipulation using DEP", ARPN Journal of Engineering and Applied Sciences, Vol. 10, No. 22, DECEMBER 2015.

S. Nursyahirah A. Latfi and F. Samsuri "Biochip Development for Biological Cells Manipulation using DEP", 3<sup>rd</sup> International Conference on Electrical, Control and Computer Engineering 2015 (INECCE 2015), 27 – 28 August 2015, Kuantan, Malaysia. Vol. 10, No. 22, pp. 17091 – 17094.

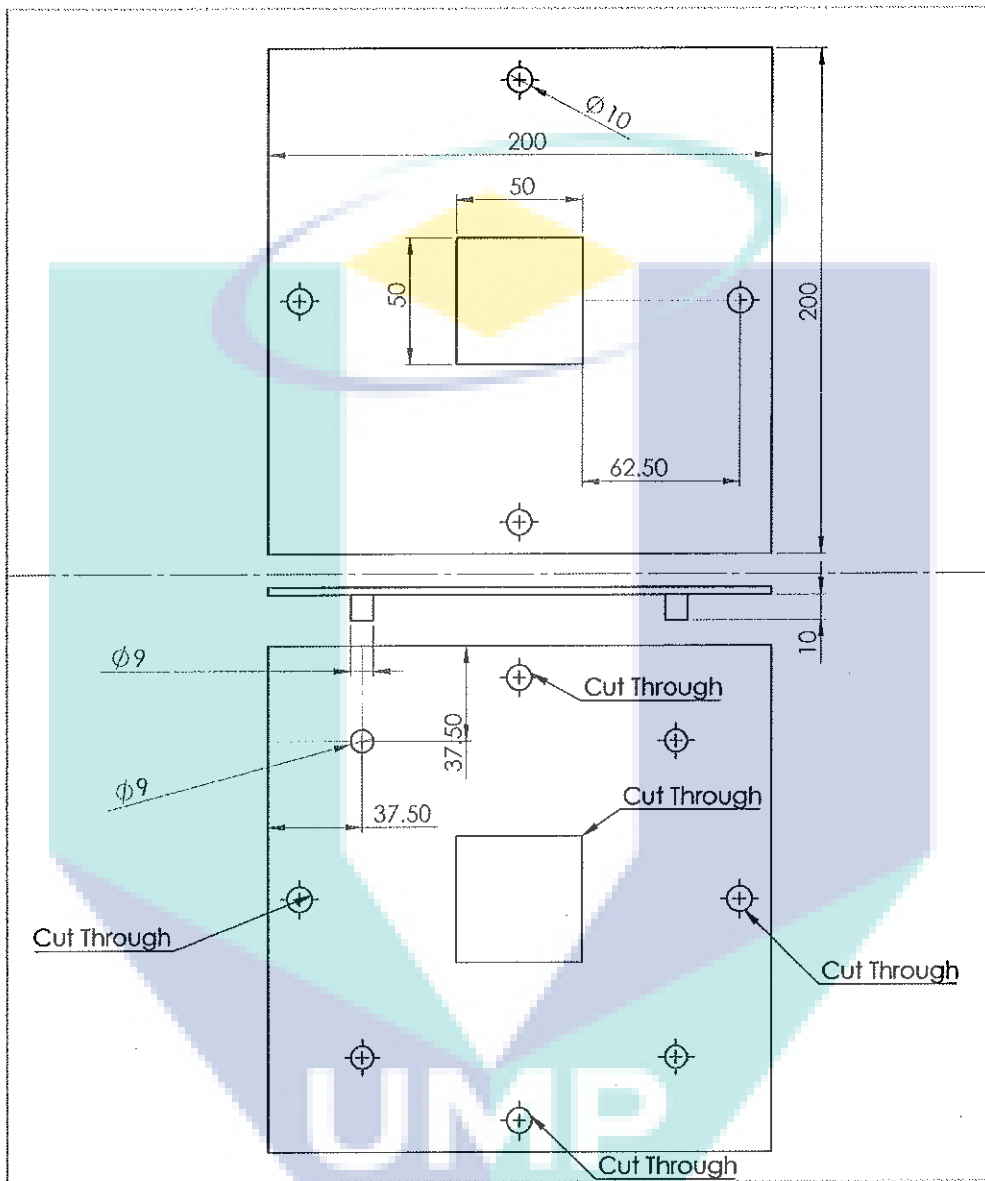




All Units in mm

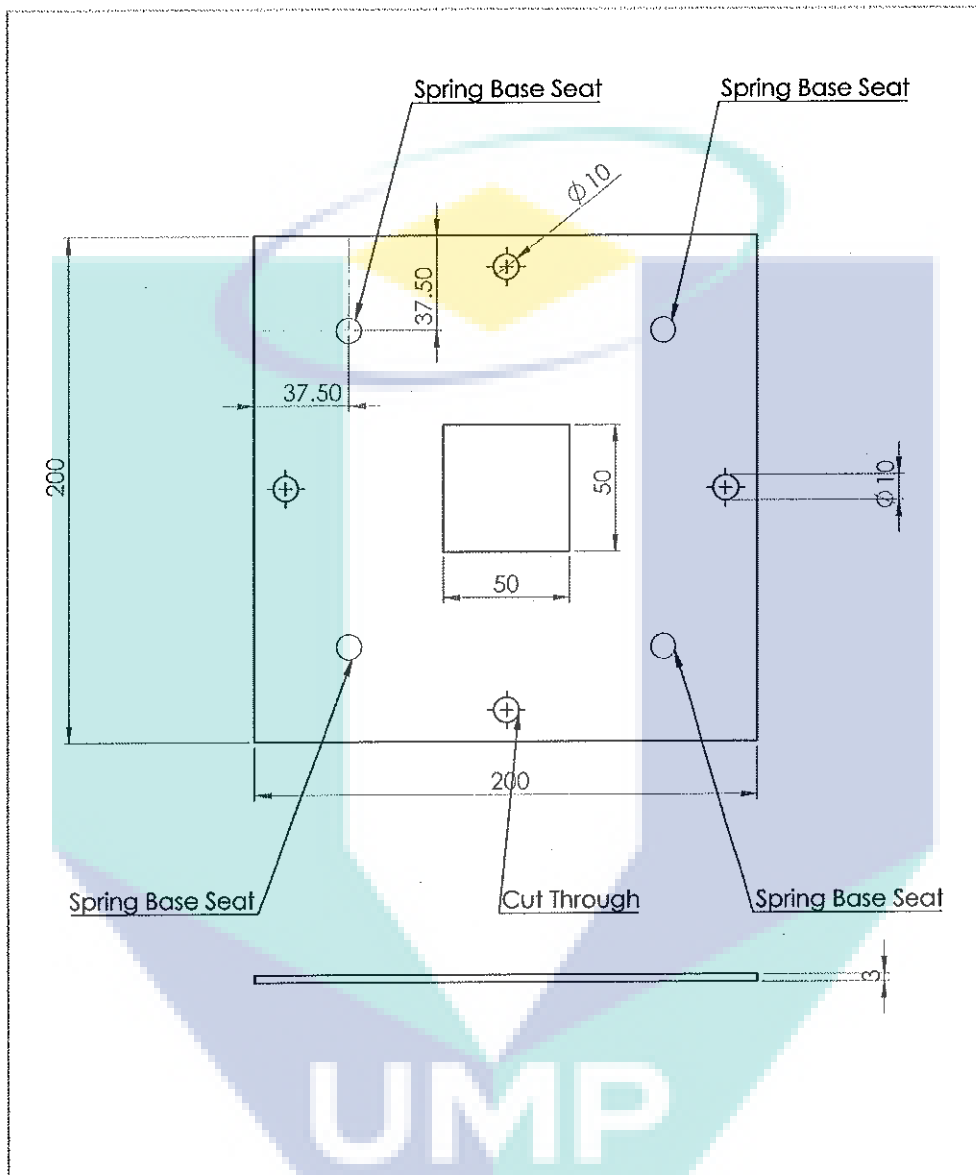
SCALE 1 : 2

UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS		FINISH:		DEBUR AND BREAK SHARP EDGES		DO NOT SCALE DRAWING		REVISION	
SURFACE FINISH:									
TOLERANCES:									
LINEAR:									
ANGULAR:									
	NAME	SIGNATURE	DATE			TITLE:			
DRAWN									
CHKD									
APPVD									
MFG									
QA					MATERIAL:	DWG NO.		Plate 1	
					WEIGHT:	SCALE: 1:5		A4	
						SHEET 1 OF 1			



UNLESS OTHERWISE SPECIFIED: DIMENSIONS ARE IN MILLIMETERS		FINISH:		DEBUR AND BRAGAR SHARP EDGES		DO NOT SCALE DRAWING		REVISION	
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APPVD:									
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QA:				MATERIAL:		DWG NO.		Plate 2	
				WEIGHT:		SCALE: 1:5		SHEET 1 OF 1	
								A4	



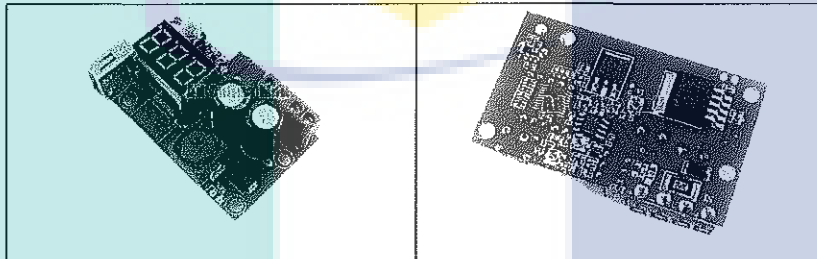


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QA					MATERIAL:	DWG NO.		A4	
					WEIGHT:	SCALE:1:5		SHEET 1 OF 1	
						Plate 3			

## TECHNICAL DATASHEETS

### TECHNICAL SPECIFICATION DATA SHEET

**LED Driver DC4.0-40V to DC1.2-38V Converter BUCK Step Down Power Supply  
Regulator Module With Digital Voltmeter USB Output**



Module Name:	LM2596 Step-Down Digital Display Constant Current Module
Module Properties:	Non-isolated step-down module (BUCK)
Input voltage:	DC 4-40V (limit 40V) Please keep the Voltage margin.
Quiescent Current:	5mA without voltmeter ammeter
Output voltage:	DC 1.2-38V continuously adjustable
Output Current:	3A MAX, Please enhance heat dissipation if exceed 2A.
(It is related with the input, the output pressure different. the greater of the output voltage different, the smaller the current.)	
Constant current range :	0.1-3A
Output power:	= Output voltage * 3A
Such as:	Output 5V * 3A = 15W,
12V * 3A =	36W, 24V * 3A = 72W,
Operating temperature:	-40 to +85 ° C (ambient temperature is too high, please enhance heat dissipation)
Operating Frequency:	150KHz
Conversion efficiency:	up to 95% (efficiency is related input,output voltage, current, voltage difference )

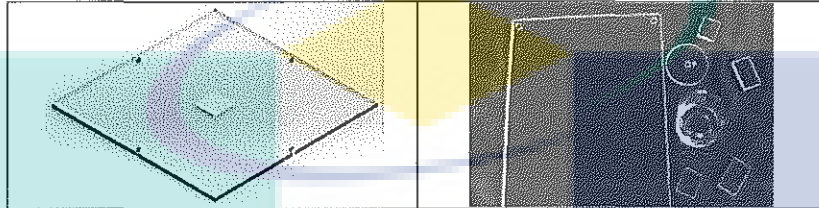
- Input Reverse Polarity Protection: None, (if you need you can string into the diode)
- Output prevent anti-irrigation: none,(if you need you can string into the diode)
- Identification resistor: Tablet PC, pad, phone (some phones identification circuit is different, need to be adjusted)
- Voltmeter minimum resolution: 0.05V/0.05A (10V following automatic switching decimal point)
- Installation: four pcs 3mm screws
- Wiring: no need welding output terminals
- Module dimensions: length 60mm \*width 35mm\* height 20mm

#### Applications:

1. DIY a regulated power supply, the output can be 1.2-38V adjustable with voltage and current display
2. The power for your electronic devices can according to your system set output voltage value.
3. As the vehicle power supply for your laptop, PDA, or a variety of digital products supply.
4. The solar panel regulator.
5. DIY high current mobile power with a single lithium battery can be boosted to 5V, comes with USB port and identification resistor, and a large current of 2.5A output to several phones simultaneously charging.

### TECHNICAL SPECIFICATION DATA SHEET

Clear Quartz Glass Plate 150\*150\*1.5mm Quartz Window



Clear quartz glass plate 150*150*1.5mm			
Parity	99.99%	UV transmission	90%
Compressive Strength	>1100 Mpa	Coefficient of thermal expansion	5.5*10 <sup>-7</sup> cm/ cm. °C
Bending Strength	67 Mpa	Hot work temperature	1750~2050 °C
Tensile Strength	48.3 Mpa	The temperature for a short time	1500 °C
Poisson's Ratio	0.14~0.17	The temperature for a long time	1200 °C
Elastic Modulus	71700 Mpa	Resistivity	7*10 <sup>7</sup> Ω.cm
Shearing Modulus	31000 Mpa	Dielectric Strength	250~400Kv/ cm
Mohs Hardness	5.3~6.5 (Mohs Scale)	Dielectric Constant	3.7~3.9
Deformation Point	1350°C	Dielectric absorption coefficient	<4*10 <sup>4</sup>
Specific Heat (20~350°C)	670J/ kg °C	Dielectric loss coefficient	<1*10 <sup>4</sup>

Applications:

\*Applicable in: Optical, Chemical, Electricity & Semiconductor


UMP

**TECHNICAL SPECIFICATION DATA SHEET**



**SUNNY SCORE** Sdn. Bhd  
星科有限公司

**Spring Coil**

Type/ Color	Type	Inside Diameter		Diameter length		Available Mx Bend	Load *N (kgf)	
		min.	max.	min.	max.		min.	max.
	SF	Ø 8 (Ø 4)	Ø 60	15	300	40 % ( 100 )	58.8 ( 6 )	2255.5 ( 230 )
						50 % ( 30 )	78.5 ( 8 )	2824.3 ( 288 )

**UMP**

High Efficacy  
365nm UV LED Emitter  
**LZ4-00U600**



**Key Features**

- High Efficacy 365nm 11W UV LED
- Ultra-small foot print – 7.0mm x 7.0mm
- Surface mount ceramic package with integrated glass lens
- Very low Thermal Resistance (1.1°C/W)
- Individually addressable die
- Electrically neutral thermal path
- Highest Radiant Flux density
- JEDEC Level 1 for Moisture Sensitivity Level
- Lead (Pb) free and RoHS compliant
- Reflow solderable (up to 6 cycles)
- Emitter available on Standard and Serially connected MCPCB (optional)

**Typical Applications**

- Curing
- Sterilization
- Medical
- Currency Verification
- Fluorescence Microscopy
- Inspection of dyes, rodent and animal contamination,
- Leak detection
- Forensics

**Description**

The LZ4-00U600 UV LED emitter provides superior radiometric power in the wavelength range specifically required for applications like curing, sterilization, currency verification, and various medical applications. With a 7.0mm x 7.0mm ultra-small footprint, this package provides exceptional optical power density. The patented design has unparalleled thermal and optical performance. The high quality materials used in the package are chosen to optimize light output, have excellent UV resistance, and minimize stresses which results in monumental reliability and radiant flux maintenance.





## FlexiForce<sup>®</sup>

### Standard Model A201

The FlexiForce A201 is our standard sensor and meets the requirements of most customers. The A201 is a thin and flexible piezoresistive force sensor that is available off-the-shelf in a variety of lengths for easy proof of concept. These ultra-thin sensors are ideal for non-intrusive force and pressure measurement in a variety of applications. This sensor is designed to use with your own electronics or multimeter.

#### BENEFITS

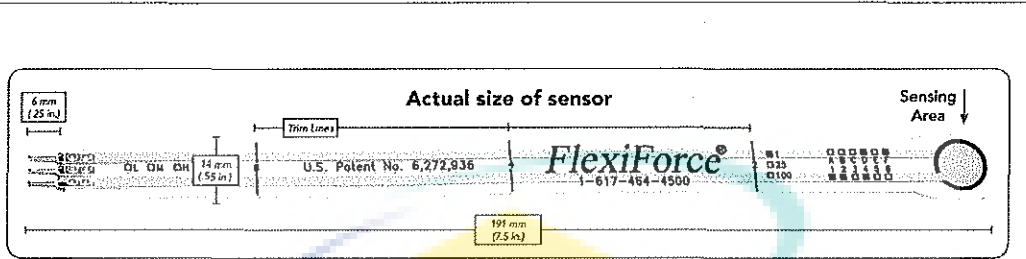
- Thin and flexible
- Easy to use
- Convenient and affordable

#### PHYSICAL PROPERTIES

Thickness	0.203 mm (0.008 in.)
Length	191 mm (7.5 in.)* (optional trimmed lengths: 152 mm (6 in.), 102 mm (4 in.), 51 mm (2 in.))
Width	14 mm (0.55 in.)
Sensing Area	9.53 mm (0.375 in.) diameter
Connector	3-pin Male Square Pin (center pin is inactive)
Substrate	Polyester (ex: Mylar)
Pin Spacing	2.54 mm (0.1 in.)

✓ ROHS COMPLIANT

\* Length does not include pins, please add approximately 6mm (0.25 in.) for pin length for a total length of approximately 197 mm (7.75 in.)

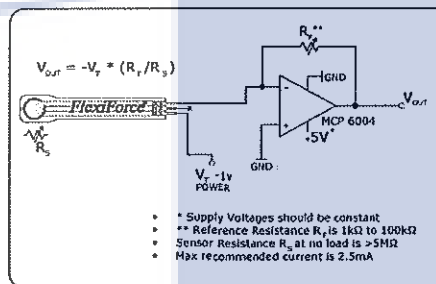


### STANDARD FORCE RANGES (as tested with circuit shown below)

- 4.4 N (0 - 1 lb)
- 111 N (0 - 25 lb)
- 445 N (0 - 100 lb)

In order to measure forces above 100 lb (up to 1000 lb), apply a lower drive voltage (-0.5 V, -0.10 V, etc.) and reduce the resistance of the feedback resistor (1kΩ min.) Conversely, the sensitivity can be increased for measurement of lower forces by increasing the drive voltage or resistance of the feedback resistor.

### Recommended Circuit



	Typical Performance	Evaluation Conditions
Linearity (Error)	< ±3%	Line drawn from 0 to 50% load
Repeatability	< ±2.5% of full scale	Conditioned sensor, 80% of full force applied
Hysteresis	< 4.5 % of full scale	Conditioned sensor, 80% of full force applied
Drift	< 5% per logarithmic time scale	Constant load of 111 N (25 lb)
Response Time	< 5µsec	Impact load, output recorded on oscilloscope
Operating Temperature	-40°C - 60°C (-40°F - 140°F)	Time required for the sensor to respond to an input force

- Force reading change per degree of temperature change = 0.36%/°C (±0.2%/°F)



ISO 9001 & 13485



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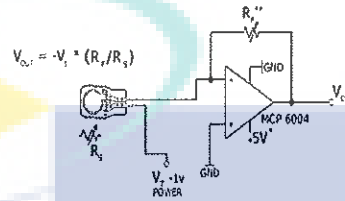
# Calibration Quick Start Guide for FlexiForce® Sensors

## Introduction

Conditioning the FlexiForce sensors before every use is recommended. In addition, calibrating the sensors is recommended before initial use. Follow the procedure below to Condition and Calibrate the sensors.

This procedure is meant for use with your own electronics. For testing, Tekscan recommends using the circuit shown in the diagram at right. If no circuit is available, you can use a multimeter, and measure the resistance in kilo-ohms.

*Note: Tekscan does not provide the circuit.*



## Part 1: Conditioning

Before using the sensors it is recommended that you condition the sensors. This process will "break in" the sensor and should be done before calibration and before every use for best results.

Place 110% (or more) of the maximum test load onto the sensor for approximately 3 seconds. For example, if the maximum test load is 10 pounds, place 11 pounds onto the sensor. Remove the load from the sensor. Repeat 4-5 times. When finished, proceed to Part 2: Calibration.

## Part 2: Calibration for Static Forces

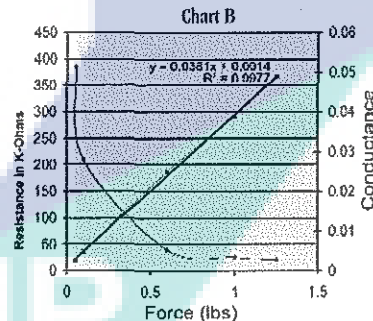
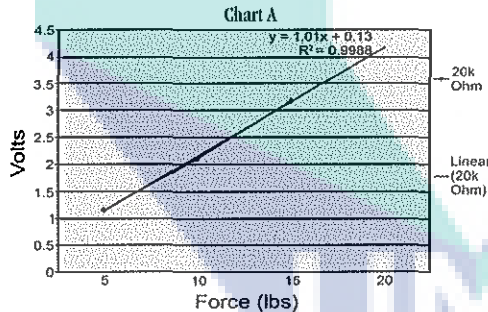
**Step 1.** Place 1/3 of the test weight on the sensor. Leave the weight on the sensor the same amount of time (before recording the output) as you will in your actual experiment. This helps minimize the drift error. Record the output, then remove the weight from the sensor.

**Step 2.** Place 2/3 of the test weight on the sensor, again waiting the approximate amount of time. Record the output. Remove weight from the sensor.

**Step 3.** Place the full test weight on the sensor. Wait the approximate amount of time again, and record the output. Remove the weight from the sensor. If using the recommended circuit, 3 sets of data are adequate. If using a multimeter, gather two more sets of data for a 5-point chart.

**Step 4.** Gather each set of data (Sensor Output vs Force applied) and plot the data on a graph. If using our recommended circuit or your own electronics, sensor output should be plotted as Voltage vs. Force (Chart A below). If using a multimeter, sensor output should be plotted as Conductance (1/Resistance) vs. Force (Chart B below). This gives a linear plot. You can then draw a line of best fit, or calculate one with MS Excel.

**Step 5.** Use the equation for the line of best fit and the sensor output to determine the force of unknown loads on the sensor during the experiment.



*Note: If testing involves dynamic forces instead of static force, this must be accounted for in the calibration process. This is due to a rise time associated with the output. Rise time refers to how long it takes the sensor to settle at the appropriate value within our error limits. The rise time for FlexiForce sensors is between 0.1 - 0.3 seconds (the response time is <math><5\mu</math> seconds). If your application involves a quick impact, the recommended method is to calibrate the sensor dynamically against a load cell with a quicker rise time. This allows you to compare the responses of both the sensor and the load cell. The amplitude of the FlexiForce sensor will be smaller than that of the load cell. The difference can be calculated by comparing the amplitudes after several tests. If a load cell is not available, the next recommendation would be to calibrate the sensor statically and use the sensor for comparative studies.*

Tekscan, Inc. 307 West First St., South Boston, MA 02127  
tel: 617.464.4500/800.248.3669 • fax: 617.464.4266  
email: marketing@tekscan.com • web: www.tekscan.com



**Product Information**  
**Electronics**

**DOW CORNING**

**Sylgard® 184 Silicone Elastomer**

**FEATURES & BENEFITS**

- Flowable
- Room temperature and heat cure
- Good dielectric properties
- Rapid, versatile cure processing controlled by temperature
- High transparency allows easy inspection of components

**COMPOSITION**

- Two-part
- 10 to 1 mix ratio
- Polydimethylsiloxane elastomer

Transparent encapsulant with good flame resistance

**APPLICATIONS**

Sylgard® 184 Silicone Elastomer is suitable for:

- LED Lighting encapsulation
- Power supplies
- Connectors
- Sensors
- Industrial controls
- Transformers
- Amplifiers
- High voltage resistor packs
- Relays
- Adhesive/encapsulant for solar cells
- Adhesive handling beam lead integrated circuits during processing

**TYPICAL PROPERTIES**

Specification Writers: These values are not intended for use in preparing specifications. Please contact your local Dow Corning sales office or your Global Dow Corning Connection before writing specifications on this product.

Property	Unit	Result
One or Two Part		Two
Color		Colorless
Viscosity (Base)	cP	5100
	Pa-sec	5.1
Viscosity (Mixed)	cP	3500
	Pa-sec	3.5
Thermal Conductivity	btu/hr ft °F	0.15
	W/m °K	0.27
Specific Gravity (Cured)		1.03
Working Time at 25°C (Pot Life - hours)	hours	1.5
Cure Time at 25°C	hours	48
Heat Cure Time at 100°C	minutes	35
Heat Cure Time at 125°C	minutes	20
Heat Cure Time at 150°C	minutes	10
Durometer Shore		43
Dielectric Strength	volts/mil	500
	kV/mm	19

## TYPICAL PROPERTIES (Continued)

Property	Unit	Result
Volume Resistivity	ohm*cm	2.9E+14
Dissipation Factor at 100 Hz		0.00257
Dissipation Factor at 100kHz		0.00133
Dielectric Constant at 100 Hz		2.72
Dielectric Constant at 100 kHz		2.68
Linear CTE (by DMA)	ppm/°C	340
Tensile Strength	PSI	980
	MPa	6.7
	Kg/cm <sup>2</sup>	69
Refractive Index	@ 589 nm	1.4118
Refractive Index	@ 632.8 nm	1.4225
Refractive Index	@1321 nm	1.4028
Refractive Index	@ 1554 nm	1.3997
UL RTI Rating	°C	150

### DESCRIPTION

*Dow Corning*<sup>®</sup> brand silicone 10 to 1 encapsulants are supplied as two-part liquid component kits. When liquid components are thoroughly mixed, the mixture cures to a flexible elastomer, which is well suited for the protection of electrical/electronic applications. *Dow Corning* silicone encapsulants cure without exotherm at a constant rate regardless of sectional thickness or degree of confinement.

*Dow Corning*<sup>®</sup> silicone elastomers require no post cure and can be placed in service immediately following the completion of the cure schedule. Standard silicone encapsulants require a surface treatment with a primer in addition to good cleaning for adhesion while primerless silicone encapsulants require only good cleaning.

### APPLICATION METHODS

- Automated metered mixing and dispensing
- Manual mixing

### MIXING AND DE-AIRING

The 10 to 1 mix ratio these products are supplied in gives one latitude to

tune the modulus and hardness for specific application needs and production lines. In most cases de-airing is not required.

### PREPARING SURFACES

In applications requiring adhesion, priming will be required for many of the silicone encapsulants. For best results, the primer should be applied in a very thin, uniform coating and then wiped off after application. After application, it should be thoroughly cured prior to application of the silicone elastomer. Additional instructions for primer usage can be found in the information sheets specific to the individual primers.

### PROCESSING/CURING

Thoroughly mixed *Dow Corning* silicone encapsulant may be poured/dispensed directly into the container in which it is to be cured. Care should be taken to minimize air entrapment. When practical, pouring/dispensing should be done under vacuum, particularly if the component being potted or encapsulated has many small voids. If this technique cannot be used, the unit should be evacuated after the silicone encapsulant has been

poured/dispensed. *Dow Corning* silicone encapsulants may be either room temperature (25°C/77°F) or heat cured. Room temperature cure encapsulants may also be heat accelerated for faster cure. Ideal cure conditions for each product are given in the product selection table.

### POT LIFE AND CURE RATE

Cure reaction begins with the mixing process. Initially, cure is evidenced by a gradual increase in viscosity, followed by gelation and conversion to a solid elastomer. Pot life is defined as the time required for viscosity to double after base and curing agent are mixed and is highly temperature and application dependent. Please refer to the data table.

### USEFUL TEMPERATURE RANGES

For most uses, silicone elastomers should be operational over a temperature range of -45 to 200°C (-49 to 392°F) for long periods of time. However, at both the low and high temperature ends of the spectrum, behavior of the materials and performance in particular