

Jul 01, 2024

Version 1

Device Fabrication Using Soft Lithography Technique V.1

DOI

<https://dx.doi.org/10.17504/protocols.io.5qpvkpydl4o/v1>

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Protocol Citation: Jann Gamboa 2024. Device Fabrication Using Soft Lithography Technique. **protocols.io**
<https://dx.doi.org/10.17504/protocols.io.5qpvkpydl4o/v1>

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Protocol status: Working

We use this protocol and it's working

Created: June 30, 2024



Last Modified: July 01, 2024

Protocol Integer ID: 102616

Keywords: using soft lithography technique standard operating procedure institute, using soft lithography technique location, soft lithography technique location, device fabrication, name of the procedure, procedure, biomedical engineering university, mb308a pi

Abstract

Standard Operating Procedure

Institute of Biomedical Engineering

University of Toronto

Name of the procedures: Device Fabrication using Soft Lithography Technique

Location: MB308A

PI: Dr. Freeman Lan

Instructor: Jann Gamboa

Protocol materials

⊗ PGMEA Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L

⊗ SU-8 3025 Kayaku Advanced Materials Catalog #SU-8 3025

⊗ Isopropyl Alcohol UofT MedStore Catalog #934-504-SCA599

⊗ Aquapel Amazon Catalog #B084R7LXY5

⊗ Sylgard-186 Curing Agent Ellesworth Adhesives Catalog #2099551

⊗ PDMS Base Ellesworth Adhesives Catalog #2099551

⊗ PDMS Ellesworth Adhesives Catalog #2099551

Potential Hazards

1. 1.  PGMEA Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L is a reproductive toxin and goes through gloves!
2. Wear cut resistant gloves when using the razor!
3. Always put the lid on when using the

Equipment

SCK-300 SCK-300P Spin Coater Kit	NAME
Spin Coater	TYPE
Intras Scientific	BRAND
SCK-300 SCK-300P Spin Coater Kit	SKU
https://instras.com/index.php/spin-coaters/	LINK



Note: The wafer could come off and cut you, or

 SU-8 3025 Kayaku Advanced Materials Catalog #SU-8 3025 could spray everywhere.

4.  Aquapel Amazon Catalog #B084R7LXY5 burns the eyes! Put on safety goggles when using

Equipment Preparation

- 2 Hot Plates and Oven

2.1 The first step consists of turning one hot plate to 95 °C and another hot plate to ~

200 °C

2.2 Turn on the

Equipment

BLACK+DECKER 4-Slice Convection Oven, Stainless Steel, TO1313SBD

Oven

BLACK + DECKER HOME

B00GGFHH4U

https://www.amazon.ca/Toaster-Toasting-Stainless-Black-TO1313SBD/dp/B00GGFHH4U?pd_rd_w=pGvJp&content-id=amzn1.sym.520cbcec-61b2-4146-be71-5d74f7119e7c&pf_rd_p=520cbcec-61b2-4146-be71-5d74f7119e7c&pf_rd_r=J0XFD7VAD73H179R4K83&pd_rd_wg=7MTZ7&pd_rd_r=cc1b57e



by turning the timer to "stay on" and the temperature to 60 °C .

3 Equipment Checklist:

1. Tweezers (2)

2. Pyrex dish for the

PGMEA Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L

3. Isopropyl Alcohol UofT MedStore Catalog #934-504-SCA599 waste beaker

4. PGMEA Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L waste beaker

5. SU-8 3025 Kayaku Advanced Materials Catalog #SU-8 3025 solid Waste

Container

6. Aluminum foil

7. Double sided tape

8. Glass Slabs (for exposure)

9. Timers

4

Equipment

SCK-300 | SCK-300P Spin Coater Kit

NAME

Spin Coater

TYPE

Intras Scientific

BRAND

SCK-300 | SCK-300P Spin Coater Kit

SKU

<https://instras.com/index.php/spin-coaters/>

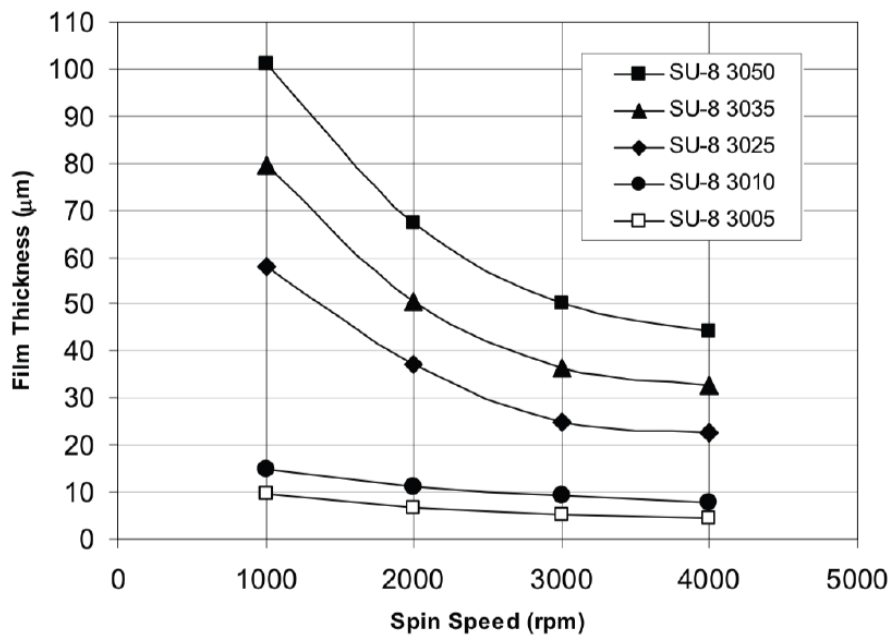
LINK



4.1 Ensure that the spin coater cover and base are covered with aluminum foil.

4.2 Ensure that the spin coater is programmed to the desired 2-step rpm (1000 rpm for  00:00:10 and the appropriate rpm for  00:00:30 ; refer to Figure 1)

40s



**Figure 1. SU-8 3000 Thickness vs. Spin Speed
(21°C US & EU)**

Figure 1 is from the

- 4.3 Place a piece of double sided tape on the spin coater.
The tape should cover the diameter of the spin coater stage and be centered.

- 4.4 Note: There may be times when the tape is not sticking to the spin coater stage. To mitigate this issue, clean the stage with

10m

PGMEA Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L to wash off chemicals that are preventing it from sticking:

1. Unscrew the stage portion of the spin coater
2. Place it on a separate clean beaker.
3. Pour **PGMEA Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L** onto it, just enough to submerge the surface of the stage. You can obtain the **PGMEA Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L** either from the "Used PGMEA bottle" so long as the number of times that it has been recycled is <10. Otherwise, obtain it from the fresh PGMEA squeeze bottle.
4. Agitate the beaker gently for 00:05:00

5. After  00:05:00 , pick up the stage using tweezers and wash it off for the last time with fresh
 PGMEA Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L over the same beaker.
6. Wash the stage with
 Isopropyl Alcohol UofT MedStore Catalog #934-504-SCA599 over the
 Isopropyl Alcohol UofT MedStore Catalog #934-504-SCA599 waste beaker.
7. Blow dry the spin coater stage using the Dyson technique.
8. Proceed to place the double sided tape on the spin coater.
9. Discard the
 PGMEA Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L to the "Fully depleted PGMEA waste bottle".

5

Equipment

Silicon Wafer

NAME

SU-8 Substrate

TYPE

University Wafer

BRAND

ID-452

SKU

<https://order.universitywafer.com/default.aspx?cat=Silicon&diam=100mm>^{LINK}

- 5.1 Locate or prepare a beaker for the waste
 Isopropyl Alcohol UofT MedStore Catalog #934-504-SCA599 .
- 5.2 Pick up the silicon wafer using the tweezer located in the fume hood.
- 5.3 Rinse the wafer with
 Isopropyl Alcohol UofT MedStore Catalog #934-504-SCA599 .



Make sure that the  Isopropyl Alcohol **UofT MedStore Catalog #934-504-SCA599** is ending up in the waste beaker for alcohol.

- 5.4 Subsequently, use compressed air to blow the alcohol off of the wafer (using the Dyson technique; ask Jann or Freeman if you are unsure)

Spin-coating and Soft Baking

- 6 Centre the silicon wafer on the spin-coater stage.



- 6.1 Note: It is imperative to centre the silicon wafer onto the spin coater stage as it can lead to uneven coating. If this occurs, proceed to wash off the

5m

 SU-8 3025 **Kayaku Advanced Materials Catalog #SU-8 3025** on the wafer with

 PGMEA **Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L** for

 00:05:00 using the instructions above over a Pyrex dish, not the beaker.

- 7 Obtain the  SU-8 3025 **Kayaku Advanced Materials Catalog #SU-8 3025** NOT from the main SU-8 bottle but from the pre-made aliquots.

- 8 Place about  1 mL or  2 mL (the size of a quarter coin) of the

 SU-8 3025 **Kayaku Advanced Materials Catalog #SU-8 3025** on the centre of the wafer, taking care not to create air bubbles. Make sure also that you do not get any

 SU-8 3025 **Kayaku Advanced Materials Catalog #SU-8 3025** on the neck of the bottle because it would then be hard to close the bottle.

- 8.1 Note 1: DO NOT let the

 SU-8 3025 **Kayaku Advanced Materials Catalog #SU-8 3025** bottle be open for a longer period of time because the compound quickly evaporates and changes the compound in the bottle.

- 8.2 Note 2: Note that  SU-8 3025 **Kayaku Advanced Materials Catalog #SU-8 3025** solid wastes should only be placed in the yellow container that is marked "SU-8 Solid Waste"

- 9 Spin the wafer according to the appropriate rpm (1000 for  00:00:10 and refer to Figure 1 for the appropriate rpm for  00:00:30)

40s

10 After spinning, pick up the wafer on its edge and place it on the  95 °C hot plate for

10m

 00:10:00

10.1 Note 1: Make sure that the double sided tape from the spin coater is not stuck on the bottom of the wafer before placing it on the hot plate.

10.2 Note 2: Adjust the soft bake times according to the thickness of the channel

THICKNESS microns	SOFT BAKE TIMES minutes @ 95°C
4 –10	2–3
8–15	5–10
20–50	10–15
30–80	10–30
40–100	15–45

Photolithographic Exposure

30s

11 Place the wafer and the print out of the mask in between two pieces of glass such that the order is:

Glass | wafer | mask | Glass ← UV Light

11.1 Note 1: Make sure that the mask is facing up – that is, the description (writings) on the mask is facing up. You can tell that the mask is facing up if you can read the description.

12 Important: Wear the UV glasses.



13 Ensure that the



Equipment

UV Flashlight

UV Flashlight

Alonefire

B09J885Q6N

https://www.amazon.ca/Alonefire-Flashlight-Rechargeable-Ultraviolet-Protective/dp/B09J885Q6N/ref=sr_1_12?crid=1W9VMOREO3W7W&dib=eyJ2ljojMSJ9.ZlAPTDOOraxzj_1YXHz45WS-OoVN9u2B37ltG3nYUWLfH_f8h0nVdvwxBebzIGtLabjz83tH8nmBHrLPpg5SNN_sT2IldT

is on full battery, that is, 4/4 bars.

- 14 Place the UV light apparatus over on top of the glasses. Make sure that the box is covering the entirety of the glasses. Make sure that you line up the UV light on the centre of the wafer and the mask.
- 15 Inform everyone in the lab before turning on
- 16 Expose for  00:00:30



30s

Post-Exposure Baking (PEB)

8m

- 17 Heat the wafer again by placing it on the  95 °C hot plate for  00:03:00 to  00:05:00

8m

- 17.1 Note 1: At this point you should be able to see the outlines of the channel on the wafer. No visible latent image during or after PEB means that there was insufficient exposure, temperature or both.

Channel Development

- 18 For this step, you would need a compound called **PGMEA Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L**. Locate first the bottle that says "Used PGMEA". If the number of times that the product has been reused is less than 10, proceed to use the "Used PGMEA". Otherwise, use fresh **PGMEA Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L** from the squeeze bottle or the actual bottle.
- 18.1 **WARNING 1:** **PGMEA Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L** goes through gloves – make sure that you double glove and/or change your gloves if you feel it necessary
- 18.2 **WARNING 2:** **PGMEA Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L** is a reproductive toxin – it is not good for pregnant women 
- 19 Pour **PGMEA Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L** onto the Pyrex dish, just enough to submerge the wafer, thereby developing it.
- 19.1 If the **PGMEA Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L** has been used more than 10 times, dispose of it in the PGMEA waste container and obtain it from the original bottle.
- 20 Cover the Pyrex dish using aluminum foil.
- 21 Manually agitate (gentle) the Pyrex dish every once in a while.
- 22 The development time depends on the thickness (height) of the channels. See the table below for guidance.

THICKNESS microns	DEVELOPMENT TIME minutes
4–10	1–3
8–15	4–6
20–50	5–8
30–80	6–12
40–100	7–15

Table 6. Development Times for SU-8 Developer

- 23 After the appropriate development time has passed, take out the wafer using tweezers.
- 24 Rinse the wafer with fresh

PGMEA Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L (over the Pyrex dish)
- 25 Rinse the wafer with

Isopropyl Alcohol UofT MedStore Catalog #934-504-SCA599 over the IPA waste beaker
- 26 If white precipitates arise, wash with fresh

PGMEA Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L over the PGMEA waster beaker to wash off

Isopropyl Alcohol UofT MedStore Catalog #934-504-SCA599 – NOT over to the Pyrex dish containing

PGMEA Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L , then back into Pyrex dish to develop longer.
- 26.1 Repeat steps 24-25



27 If  Isopropyl Alcohol **UofT MedStore Catalog #934-504-SCA599** doesn't generate white precipitates, then blow dry off using the Dyson technique

28 Recycle the  PGMEA **Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L** by pouring it back to the used PGMEA bottle (use the PGMEA funnel). Indicate that the  PGMEA **Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L** has been used once more by writing a line on the bottle.

28.1 Note: If the number of lines has reached 10, discard the  PGMEA **Merck MilliporeSigma (Sigma-Aldrich) Catalog #484431-4L** in the PGMEA waste container.

Hard Baking

2m

29 Place the wafer on the  200 °C hot plate for  00:02:00

2m

30 At this point you should be able to view the channels on the device under the microscope. Place the device on a clean petri dish after baking and view the channel from there using the microscopes.

31 Label the petri dish with the name of the dimensions of the channels, ID of the device, the date, your initials.

Molding a Device

2m

32 Prepare the  PDMS **Ellesworth Adhesives Catalog #2099551** by mixing the  Sylgard-186 Curing Agent **Ellesworth Adhesives Catalog #2099551** and  PDMS Base **Ellesworth Adhesives Catalog #2099551** in 1:11 ratio

32.1 For  30 g, you would need  2.5 g of the  Sylgard-186 Curing Agent **Ellesworth Adhesives Catalog #2099551** and fill the rest with the  PDMS Base **Ellesworth Adhesives Catalog #2099551** (desired final amount x 1/12 = amount of elastomer needed)

33 Mix vigorously using the Dremel tool or manually using the mixing sticks until you get an opaque colour and a lot of bubbles.

- 34 Degas or desiccate until the  PDMS Ellesworth Adhesives Catalog #2099551 is clear is free from air bubbles using the

Equipment

Vacuum Desiccator

NAME

Ted Pella

BRAND

2246

SKU

https://www.tedpella.com/desiccat_html/vacpoly.htm

LINK

Any vacuum desiccator that will fit your samples will work ^{SPECIFICATIONS}



- 35 While waiting, place the wafer on a petri dish. Cover it so that it is free from dust.

- 36 Once the de-gassing is done, pour the  PDMS Ellesworth Adhesives Catalog #2099551 on top of the wafer.

- 37 Make sure that the temperature of the oven is around  60 °C . Place it in the oven for several hours or even  Overnight



- 37.1 Important: since the temperature of the oven fluctuates drastically, place the cover of the petri dish at the bottom by placing the device on top of it so that it does not melt.



Harvesting the Device

- 38 After several hours, take the device out of the oven.

- 39 IMPORTANT: Wear the cut resistant gloves.



- 40 Cut the device mold using a scalpel. Make sure that you are not cutting into the channels and don't push too hard on the wafer or it will splinter
- 41 Peel the device mold using tweezers or your hands
- 41.1 Note 1: It is very easy to break the silicon wafer so when you are cutting or peeling off the device, be very careful not to break the wafer.
- 42 Punch the inlet and outlets of the device using the manual puncher.
- 43 Tape the device so that it would be free from dust.

Plasma Bonding the Device

- 44 Speak to Jann or Freeman about this or refer to the SOP for the Harrick Plasma Cleaner PDG-32G from the Matsuura Lab

Aquapel Treatment

5m

- 45 **IMPORTANT:** Wear safety glasses!
- 46 To make the device mold hydrophobic – cut a piece off of the aquapel syringe tubing.
- 47 Stick the tubing into the channel, push just enough to get the liquid into the droplet making a nozzle.
- 48 Push air through the channel to clear it out.
- 49 Put in the oven for  00:05:00 to dry.

5m



- 50 Seal the aquapel syringe tubing by melting the tubing end for a FEW seconds on the hot plate or lamp and sealing it with your gloved fingers.