Standard Operating Procedure

TU/e

SOP details

Title	PDMS TopoChip Inter-mould Production from the Si Master mould
Description	This SOP describes how to produce a PDMS mould from the master Si mould as a mid-step to make an OrmoMould (SOP 1.5)
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Authorized	Jan de Boer	18-4-23	

Version changes

Version	Name	Date	Changes made
1	Mehmet Tas	15-03-2021	First full version
2	Jan de Boer	23-03-2021	Adjustment with track changes
3	Mehmet Tas	10-05-2021	Comments are addressed.
4	Burcu Gumuscu	24-5-2021	Revised, final version.
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1 Purpose

This SOP describes how to prepare a negative TopoChip mould from a master Si-wafer master mould using polydimethylsiloxane (PDMS) as the mould material. This PDMS inter-mould will then be used to produce an Ormomould (SOP 1.5) for imprinting various polymeric materials.

2 Principle

PDMS is an inert, nontoxic, nonflammable, and highly flexible, widely used polymer. It is commonly used as a stamp resin in the procedure of soft lithography. It is also one of the most common materials used for flow delivery in microfluidic devices. In our labs, PDMS is used to produce a negative imprint of the topographical features from silane-treated Si wafer moulds. The surface of the to-be-imprinted mould is covered with uncured PDMS to replicate the negative of the surface features as a thin, flexible PDMS film. This film is then used to make an OrmoMould as the next step to reproduce the positive imprint of the topographical features on a hard mould for hot embossing.

3 Before You Start

You must complete the silanization treatment (SOP 1.2) of Si master moulds before you start this protocol. Once the Si mould is silanized, it should be cleaned before using the nitrogen spray gun to make sure the surface is clean. A Si mould is used to imprint PDMS, therefore it should remain clean and free from stains, scratches once it is silanized. Si mould must be kept in the protective case after use. This SOP can be used to make any type of PDMS moulds from a 4-inch Si wafer master mould, regardless of the sizes of the topographies. Before using this SOP, get an introduction to the microfabrication lab for the cleanroom (Feynman lab) and the equipment needed for this process from the super users.

4 Required materials

4.1 Workplace

This SOP should be performed in the microfabrication lab (Gemini- Noord, Feynman lab). Follow the safety protocols instructed by the lab managers and perform the experiment accordingly in allocated locations in the lab.

4.2 Equipment and disposables

- SYLGARD® 184 polydimethylsiloxane elastomer kit (Supplier: Mavorn B.V. , Catalogue Number: 1060040_S5,5K)
- Desiccator (for degassing PDMS)
- Plasma asher (Emitech K1050X)
- N_2 (Nitrogen) spray gun
- Disposable plastic cup (located next to the PDMS station)
- Disposable stir stick (located next to the PDMS station)
- Lint-free tissues

- Scale (located next to the PDMS station, dedicated to PDMS weighing only)

5 Procedure

5.1 Working procedure

1) Put on a clean pair of gloves before you handle the already silanized Si wafer. Remove the Si wafer from its protective case and blow with the nitrogen gun to remove any dust that may have accumulated.
2) Cut a square aluminium foil of roughly 120 mm x 120 mm size. Put the Si mould in the centre of the aluminium foil and form a circular mould along the edges of the Si wafer. Refrain from damaging or tearing the aluminium foil in this step. Make sure that some aluminium foil is sticking up at the side so the PDMS will not overflow. See below Figure 1. Refrain from touching the surface of the Si wafer. Do not bend or apply excessive force to the Si wafer during forming the Al mould to avoid damaging/breaking the Si wafer.

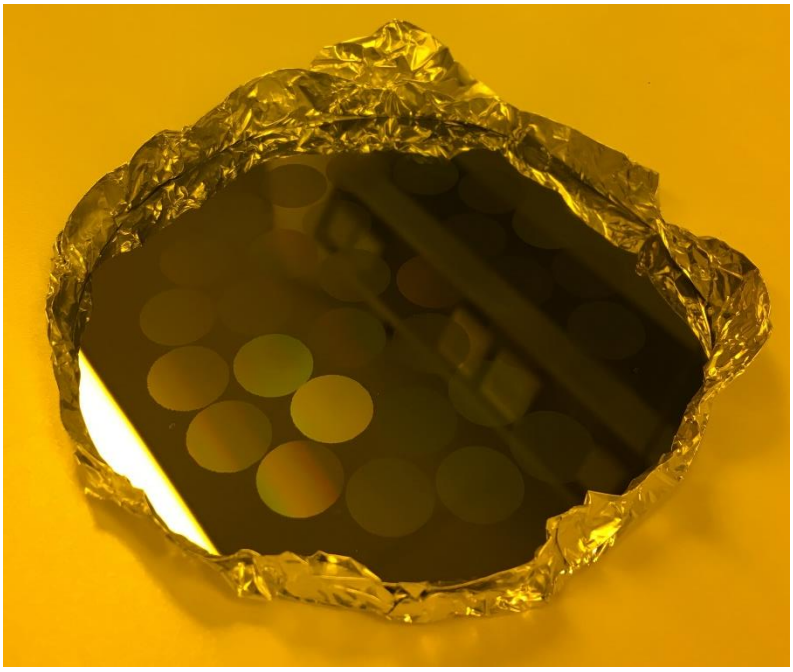
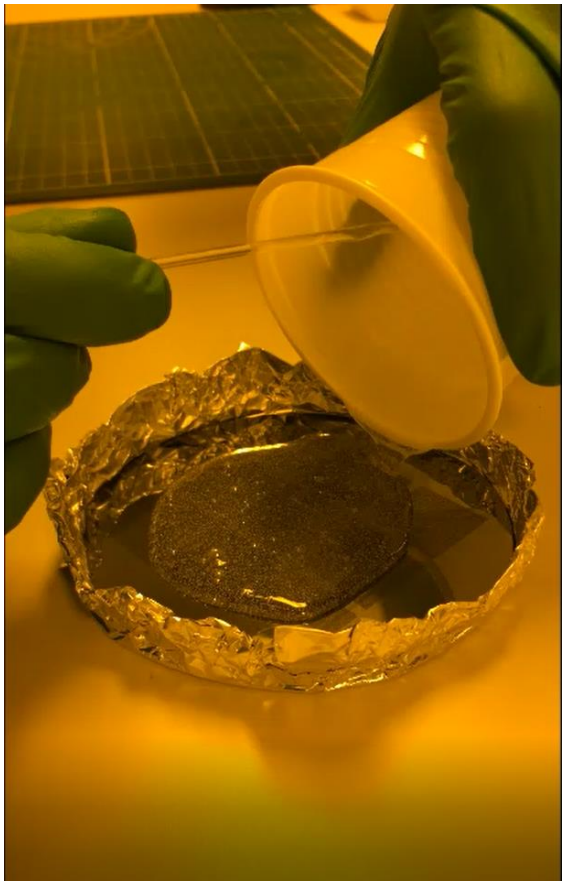


Figure 1. A Si master mould placed covered in Al foil before pouring PDMS.

3) Prepare the PDMS. For this step, the SYLGARD® 184 polydimethylsiloxane elastomer kit is used. It is supplied as two parts, the elastomer base and the curing agent which are mixed with a weight ratio of 10:1 by weight or volume, respectively. The PDMS base is a very sticky, difficult

to clean substance, make sure you use the dedicated PDMS preparation station in the microfab lab to prepare the PDMS. Use cleanroom tissue on the surfaces to prevent getting PDMS on them, if required use Isopropyl alcohol (IPA) to clean PDMS spill or drop. If it is cured, you can try to peel it off from surfaces. Mix the two parts of PDMS elastomer with a weight ratio of 10:1 in a disposable plastic cup with a stirring stick. To cast a 4" wafer, ~16 g of PDMS is needed. (part A:15g elastomer base, part B: 1.5 g curing agent), stir the solution vigorously for 2 minutes using a disposable stir stick. The appearance of the solution should turn to turbid with air bubbles from a clear appearance.

4) Pour the mixture onto the Si wafer with the aluminium foil mould slowly. Make sure that there are no gaps between the edge of the Si mould and the aluminium foil so that the uncured PDMS will not leak underneath the Si mould. This could result in an uneven thickness of the PDMS mould.



5) Place the Si mould with poured PDMS inside the desiccator. You must remove the air bubbles from the PDMS by degassing until the uncured PDMS layer is free of air bubbles. You will observe the air bubbles going towards the surfaces and disappearing because of the applied vacuum. You can remove the air bubble right after mixing (after step 5) as well however, some

bubbles will reform after pouring the PDMS onto the Si master mould and will have to repeat the degassing process.

Keep an eye on the wafer as you degas, since PDMS could overflow when all the air bubbles are surfaced. Stop the pump immediately if there is overflow and vent the desiccator very slowly to prevent the Si wafer from flipping. If the desiccator is not clean, all the airborne dirt particle could also land on the surface of your PDMS when you vent too quickly.

6) Cure the PDMS in Al foil mould either in an oven or on a hot plate at 85°C for 2 hours. Other curing temperatures are possible; the higher the temperature the faster the cure however, higher temperature will make PDMS mould more brittle and more prone to tearing/cracking, therefore avoid curing at high temperatures. Longer curing times are also possible at lower temperatures (e.g. 65 °C for min. 4 hours to max. overnight, but any temperature lower than 65 °C should not be used). Refer to manufacturer's datasheet (also available in the SOP 1.4 Appendix Folder) for various curing times if needed.

   Make sure that the Si wafer sits completely flat on the hot plate or in the oven to avoid uneven thickness of the cured PDMS film. Also, try to select a non-inclined shelf in the oven. Use a bubble level if required to make sure the hot plate/oven rack is level. Always cover the top of your sample using another aluminum foil piece to avoid the landing of external debris. In this case, make sure that the aluminium cover does not fall down onto PDMS.

7) After curing, remove and discard the aluminium foil, then peel the PDMS from the Si wafer slowly and carefully. This requires peeling 1 cm in from all edges of the Si master before you peel the bulk film from the center to prevent tearing/damaging the PDMS. If you have lines and spaces on your master, peel parallel to them.

8) Place the Si master mould back in its protective carrier wafer box. If the PDMS mould has any rough/uneven edges, you can cut them with a razor blade after peeling.

9) Take a square plastic petri dish container, place a lint-free cleanroom tissue at the base and put the PDMS mould on top. Label your PDMS mould accordingly. This PDMS mould can be used many times to make Ormomoulds. It is a good practice to track how many times a PDMS mould is used by indicating this on the container box (max 5 times is suggested due to heat and pressure application on the micron-scale strucutres). If there are any visible dust particles on the mould, wipe with a clean lint-free cleanroom tissue soaked in IPA.

10) Figure 2 below visualises the important steps for the PDMS replica fabrication. You can also refer to the short video visual in the dedicated BiS folder.

Steps	Illustrations	Descriptions
A-1		A silane-treated Si TopoChip master mould.

A-2

Pour appr. 16 ml PDMS on the wafer. Degas in a desiccator to remove air bubbles.

A-3

Cure PDMS for 2 hours in the oven (85°C) or on a hot plate. Make sure the surface is perfectly flat.

A-4

Peel PDMS from the Si mould.

Figure 2. Summary of the important steps.

5.2 Safety

Work in the Feynman lab in Gemini-Noord according to the safety regulations. Follow the instructions given in the lab introduction by the lab managers

6 Waste

When working in the Feynman lab, handle waste according to guidelines which are labelled at the waste disposal based on its categories as given below in Table 1.

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Categorisation of hazardous waste substances

HELP PROTECT SAFETY, HEALTH AND THE ENVIRONMENT

Category I	Category II	Category III	Category IV	Category V	Category VI
				N/A	N/A
Category I (diluted) inorganic acids with heavy metals pH ≤ 7	*Category II* (diluted) inorganic caustic solutions pH ≥ 7	*Category III* low halogen content organic substances	*Category IV* high halogen content organic substances	*Category V* special waste substances	*Category VI* waste substances containing special risks
laboratory chemicals (original packaging for chemicals still containing residues), contact Waste management & logistics, phone no 4343					Radioactive substances
Diluted inorganic acids (nitric acid, hydrochloric acid, etc.)	Diluted inorganic hydroxides	Liquid organic substances (alcohol, acetone, toluene, etc.)	Liquid halogenated organic substances (i.e. substances containing fluorine, chlorine, bromine or iodine)	Preparations and specimens	Biological waste
Heavy metal cations in solution (e.g. zinc, copper, nickel, lead)	Heavy metal ions in solution (e.g. zinc, copper, nickel, lead)	Solid and pasty low-halogen organic substances (including plastics)	Solid and pasty high-halogen organic substances (including plastics)	Chemically contaminated packaging/equipment	gas cylinders and pressurised containers
Cations and anions of heavy metals	Anions of metalloids	Mineral lubrication and system oils (such as sump oil)	Pesticides (containing halogen-based compounds)	Small, hazardous waste	
Solutions containing fluoride	Solutions containing cyanide	Oil emulsions (such as drill, grinder, roller and cutter oils containing water)	Waste oils contaminated with substances containing halogens	All other chemical waste that cannot be placed in categories I to IV or VI . *See the TU/e Science Park Waste Substances Manual*	For the disposal of the waste substances listed above, contact the SBD, BVF or Waste management & logistics
Waste liquid from plating and pickling baths (acid), fixing salt	Photograph developer and activator	Pesticides (halogen-free)			

For the disposal of the waste substances listed above, contact the **Waste management & logistics**

General tips
Read the 'Waste Disposal' instructions and the TU/e Science Park Waste Substances Manual (AMSO website)
Make sure waste is categorised correctly
Correctly label waste
Watch out for accidental reactions (if you have any doubts, see the list of hazardous combinations in the TU/e Science Park Waste Substances Manual)
Be aware of the fire risks associated with Category III and IV substances
Work neatly and tidily, use personal protective equipment
Use the correct packaging for collecting waste
Always close (empty) packaging
If possible, only open packaging in a fume cupboard
Fill packaging to a maximum of 90% (up to the indicator strip)
For the temporary storage of packaging, follow the 'Storage of hazardous substances in accordance with PGS 15' procedure (Appendix 1 of the TU/e Science Park Waste Substances Manual)
Call the TU/e Waste Centre before collection
If you have any doubts about specific types of waste or questions concerning (the above) procedures, etc., you should always contact your faculty's local health, safety and environment co-ordinator

Important telephone numbers:

Waste Management & logistics (AMSO)	(040 247) 4343
	(040 247) 3500 (if there is no answer call 3355)
Radiation Protection Service (SBD)	(040 247) 3355 (if there is no answer call 3500)
Biological agents safety officer (BVF)	(040 247) 2239
Emergency telephone number	**(040 247) 2222**

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Table 1: Categories of hazardous liquid waste