Supplementary Information (SI) for Lab on a Chip.

Hard-Lithography Protocol

Garry, Weitz et al. 2026

This PDF is designed for researchers who are interested in using Hard lithography for their dedicated scientific experiments. NOA 81 microfluidic devices once heat treated, eliminates channel swelling in organic solvents while also providing structural integrity with an increase in material modulus of 2 orders of magnitude (~ 2 GPa)- hence the term "hard".

The protocol is developed around the well-known PDMS "soft lithography". Beginner level understanding of PDMS microfluidics is recommended but not essential. The heat-treated devices are gas impermeable and can be surface treated using oxygen plasma to render the surfaces hydrophilic.

This document provides a step-by-step pictorial protocol. It was developed in a lab where PDMS is regularly used, therefore, the protocol should be easily implemented where PDMS fabrication facilities are present. A master mold is made prior.

Apparatus:

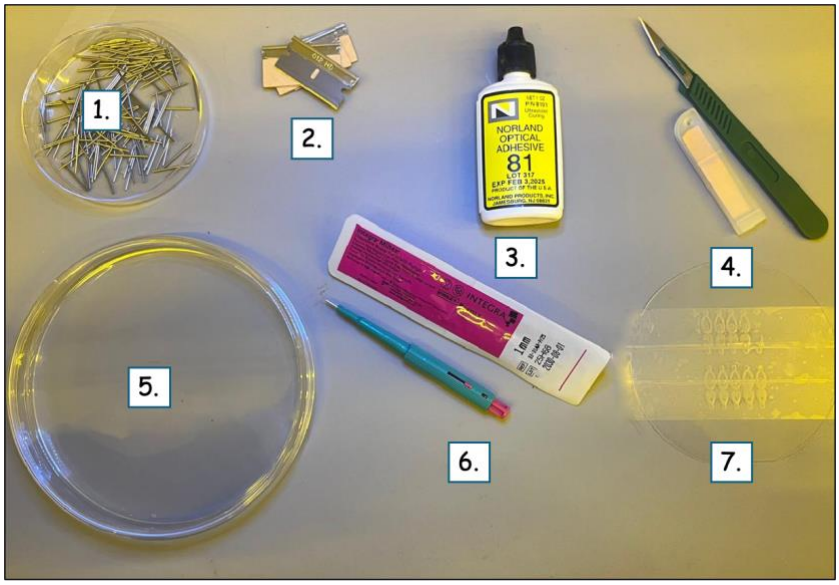
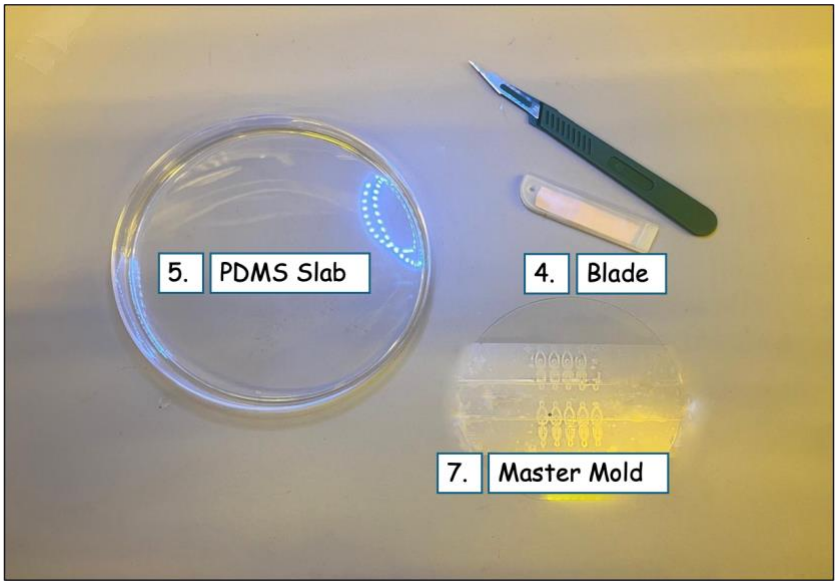


Figure 1 Apparatus: *1. Metallic Tubing Connectors, 2. Razor Blades, 3. NOA 81 Resin, 4. Surgical Blade, 5. PDMS Slab (10:1) 20g in 5" Petris Dish, 6. 1 mm Biopsy Hole Puncher, 7. Master Mold (SU-8 on 4" Glass Wafer). (see appendix for link to items)*

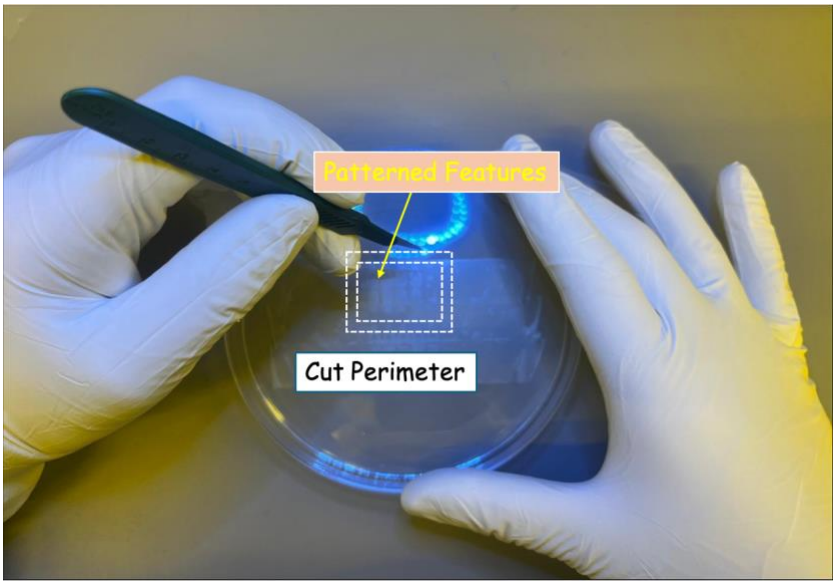
Replica Preparation:

Prior to casting NOA 81 onto a master mold, prepare a frame around the features on the master mold.

Cast 20g of PDMS onto a 5" Petris dish. Degas and cure at 80°C for 1 hr on a LEVEL hotplate.



Cut out frame by following the dotted lines around the perimeter of the features present on your master mold.



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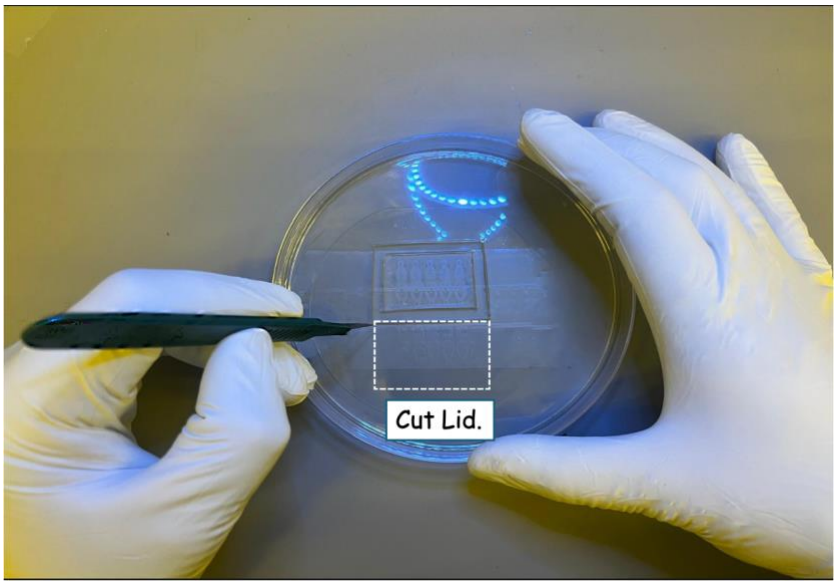
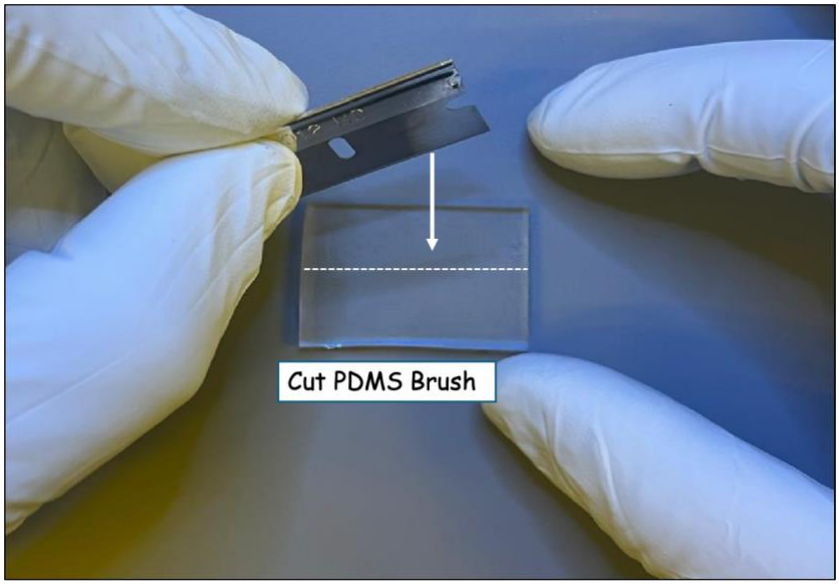
Cut out lid to the shape of the frame.



To help remove any trapped air bubbles after pouring NOA over the mold, make a brush from the excess PDMS. Cut using a razor blade to the shape of a brush.



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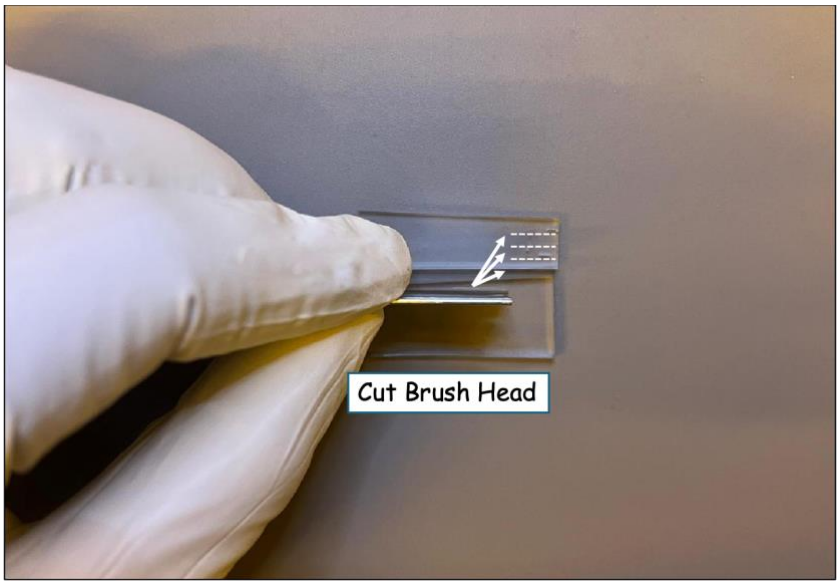
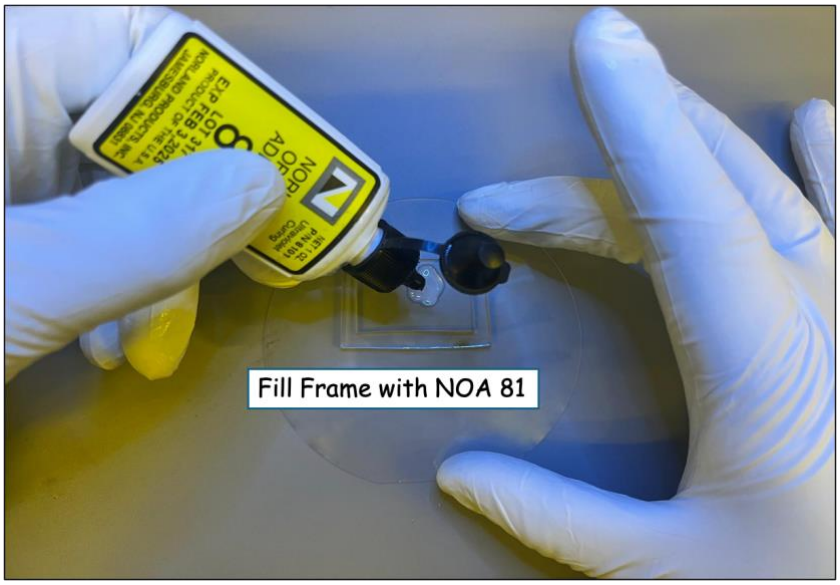
Slice lines in PDMS to make a brush-like structure. See dotted lines as an example.



Place frame over master mold SU-8 features and fill with NOA 81. Gently dispense liquid.



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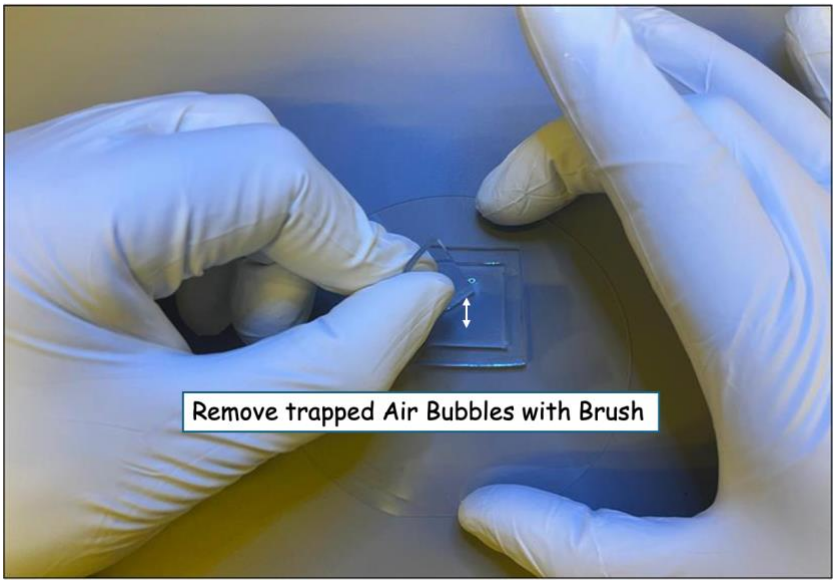
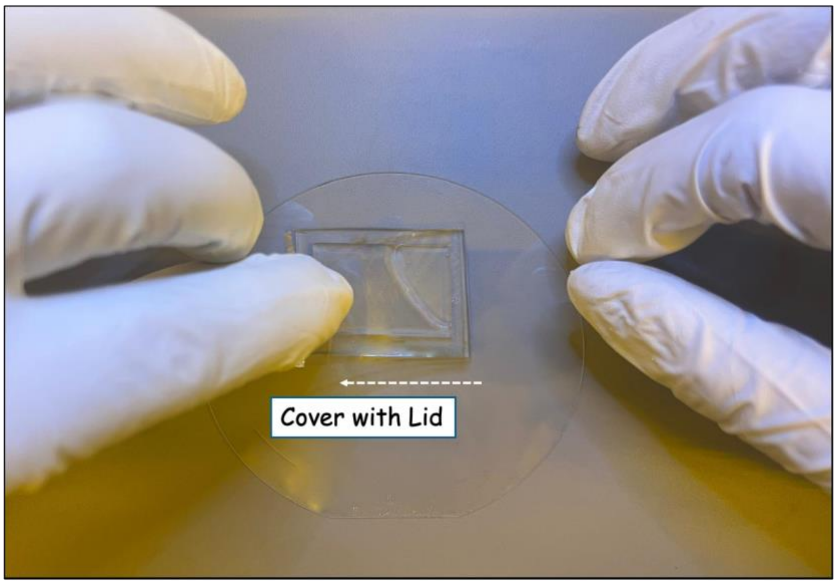
Using the PDMS brush, remove any trapped air bubbles that are stuck to the SU-8 features on the master mold. (There is no need to use vacuum if this step is done correctly).



Once removed, place lid over the frame to seal uncured NOA 81. Start from one side and carefully position lid to prevent any air bubbles from getting trapped.



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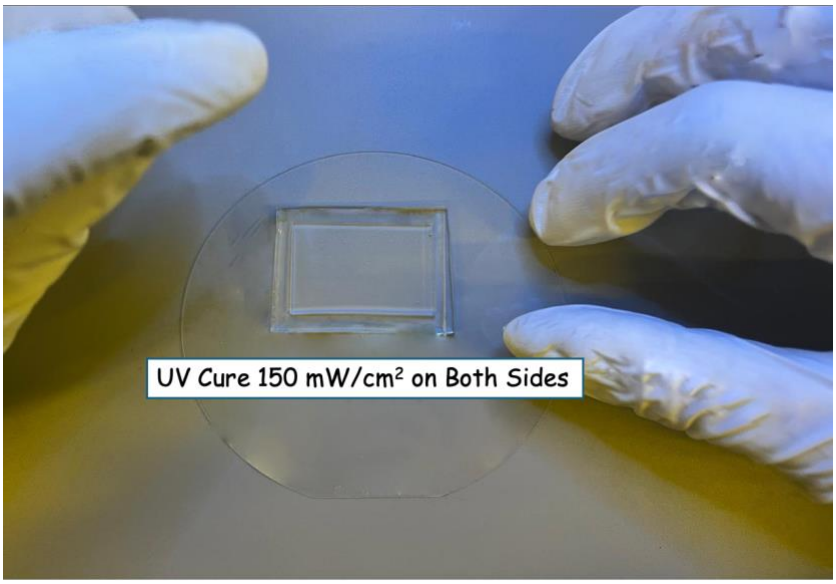
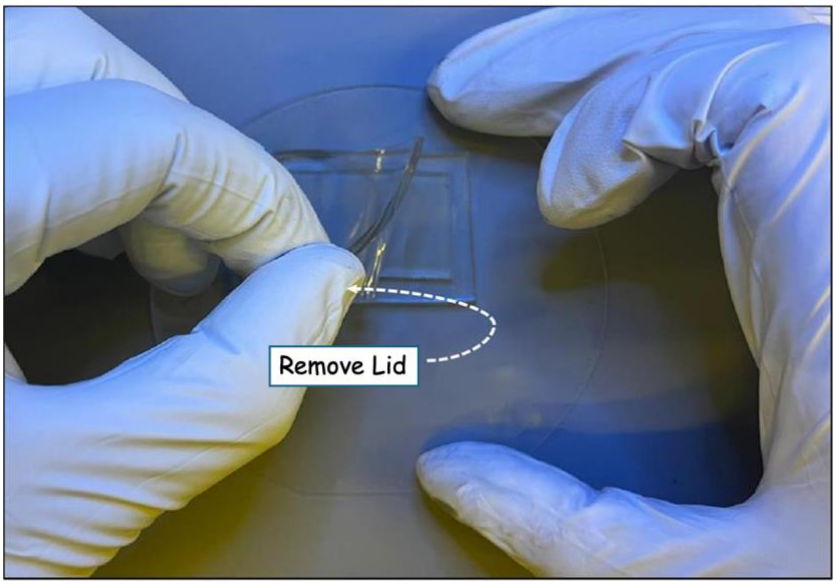
UV cure 150 mW/cm^2 on both sides to cure NOA 81.



Remove Lid.



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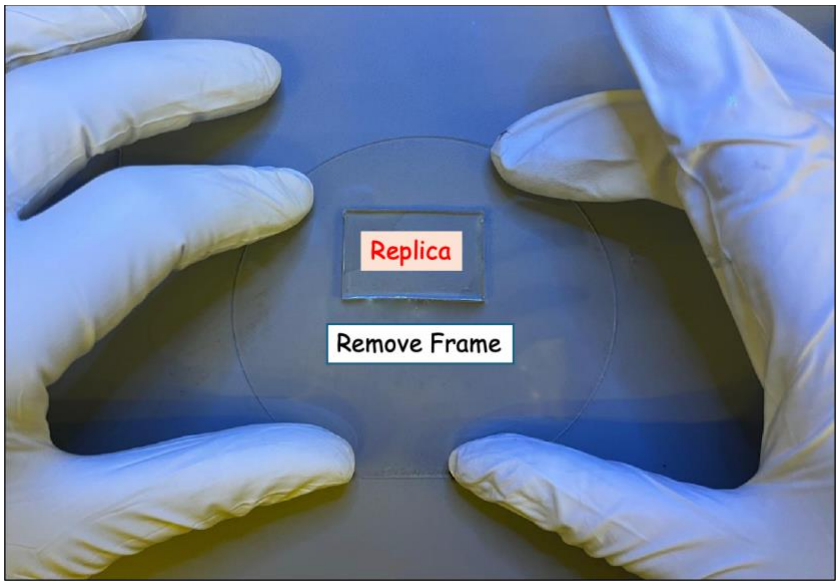
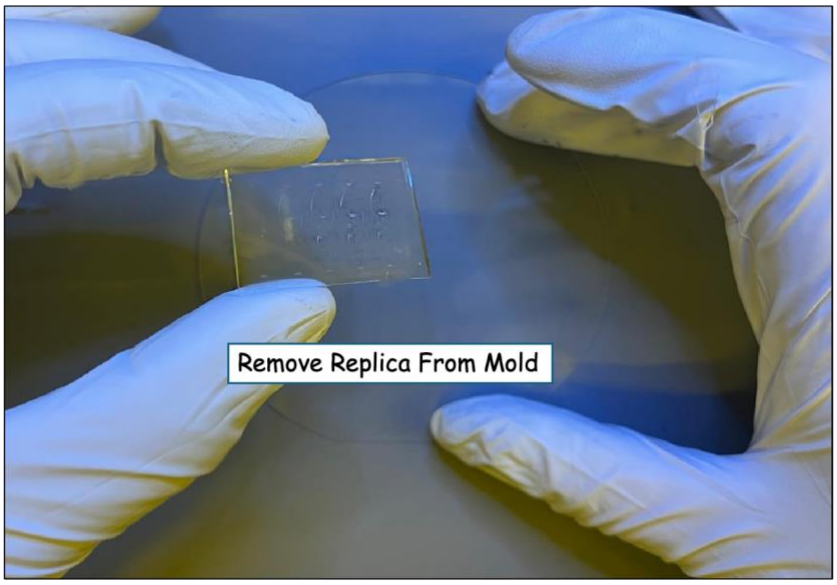
Remove Frame to reveal NOA 81 replica.



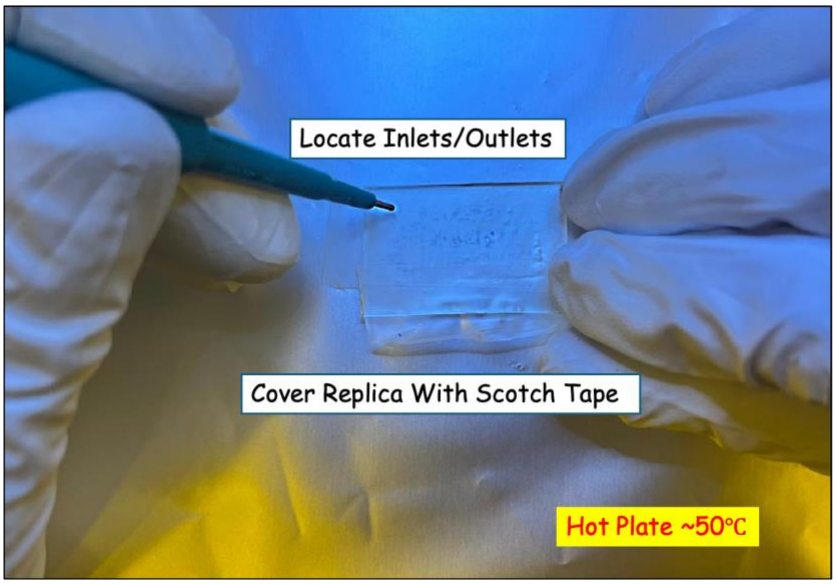
Detach from mold with the help of razor blade.



Punching Holes for Inlet/Outlets:

Cover features with scotch tape and place on hotplate set to 50°C.

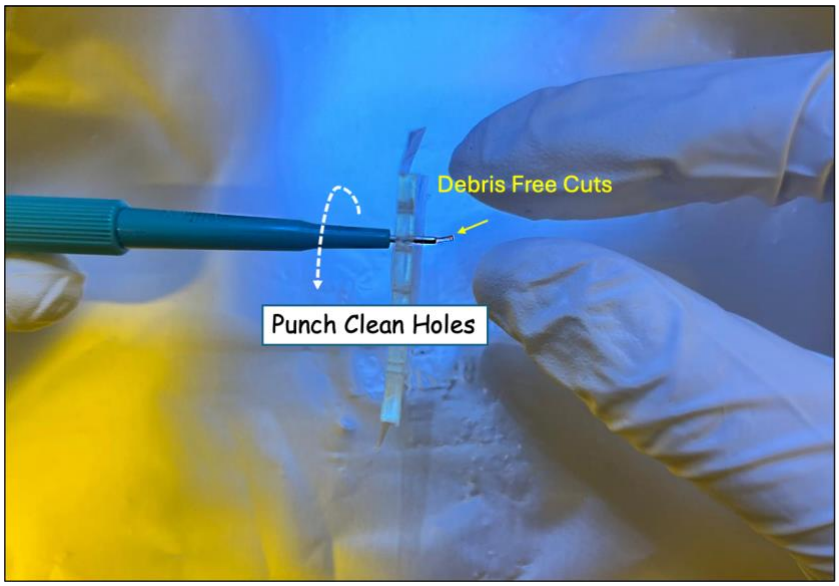
After 2-3 mins locate areas to punch holes.



Punch Holes with 1mm Biopsy Pen.

Initially insert, then twist pen to remove clean cut hole.

Notice that the part removed is free from debris. If not, adjust temperature or replace hole puncher.



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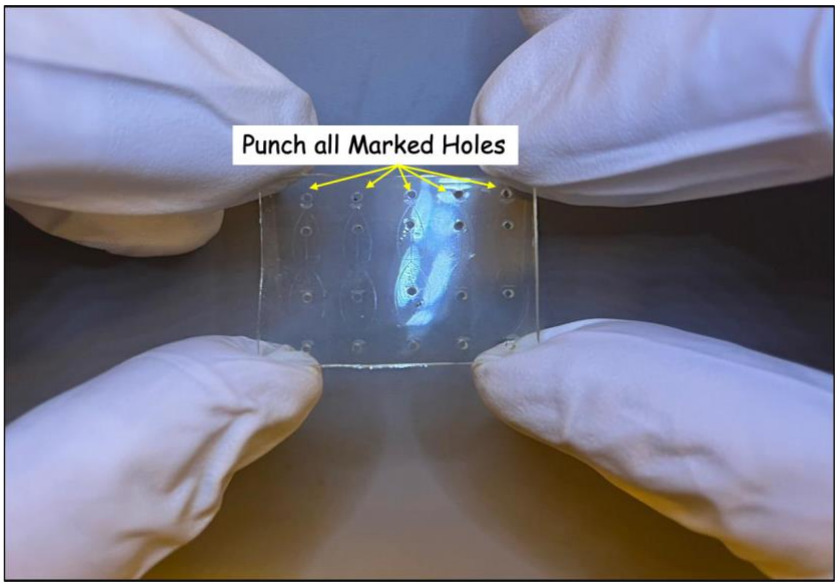
Punch all marked holes.

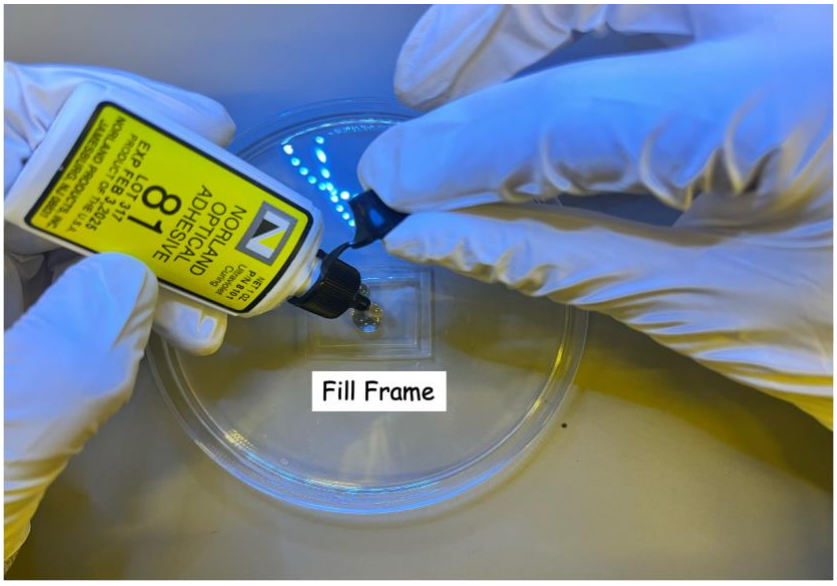
The better the hole punch, the less chances of device contamination.



Substrate Preparation:

Place frame on flat piece of PDMS.

Pour NOA 81 into frame and remove any air bubbles.



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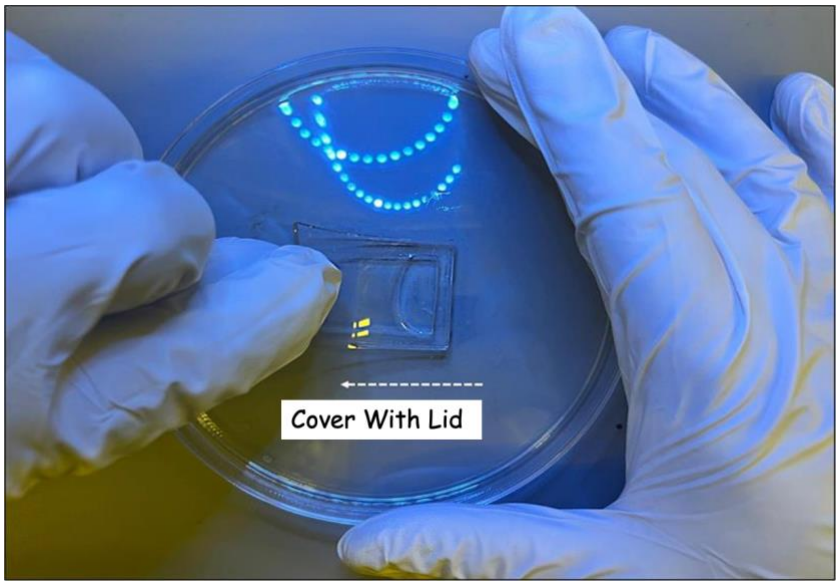
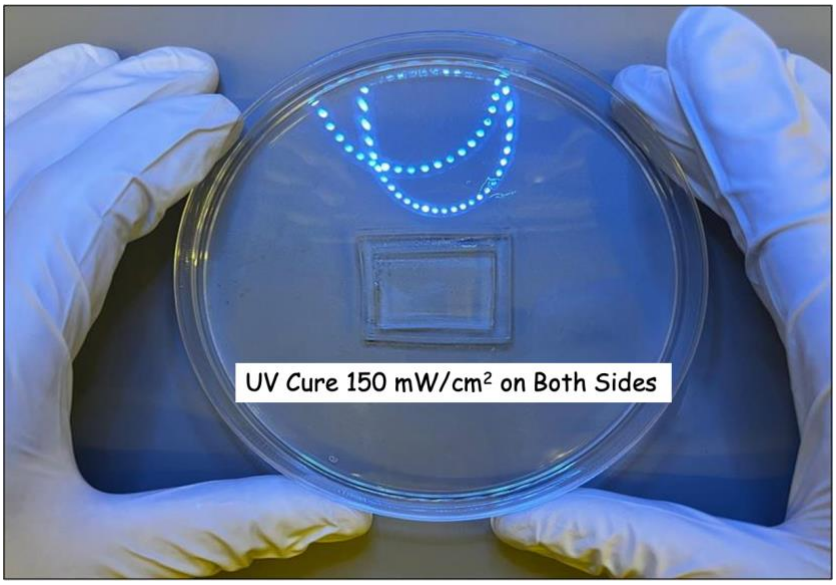
Cover with lid to create flat surface.



UV cure 150 mW/cm^2 on both sides.



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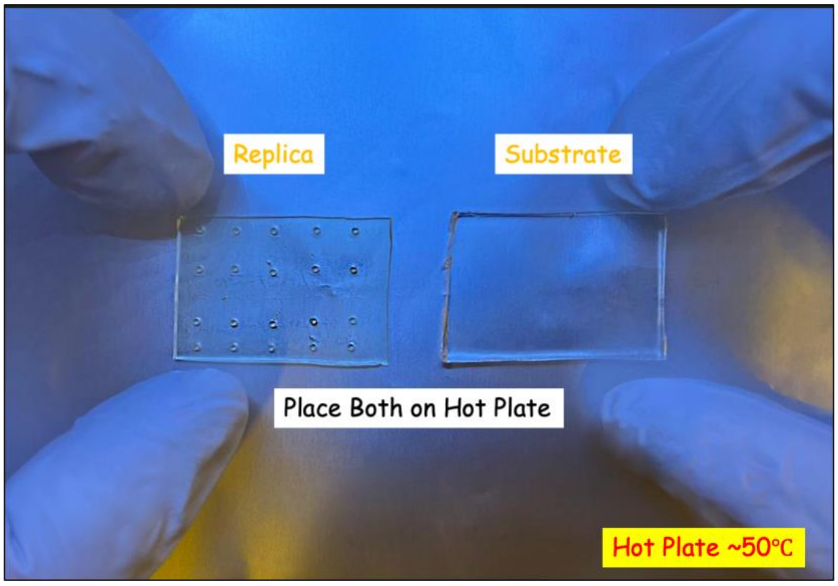
Bonding Device:

Place the replica and substrate onto a hotplate set to 50°C for 3-5 mins.



Place replica on top of substrate and press firmly together using fingers. Remove any large air bubbles.

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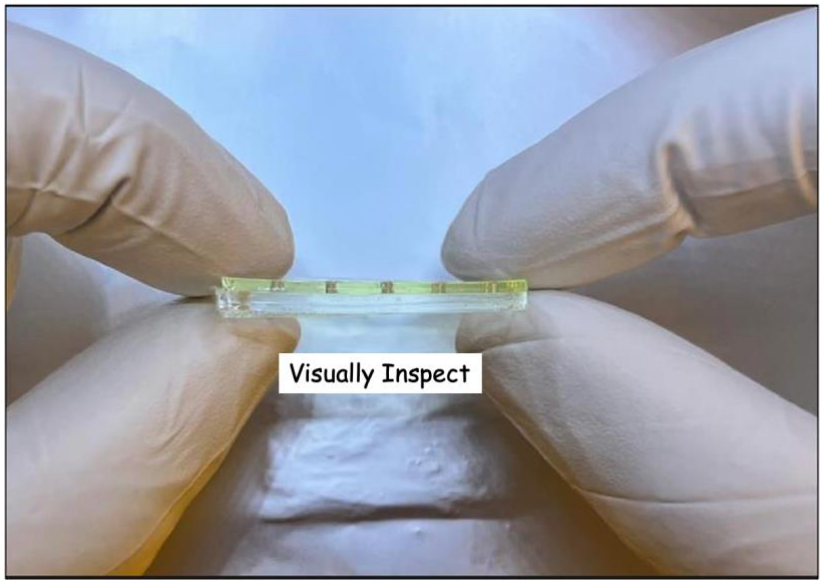
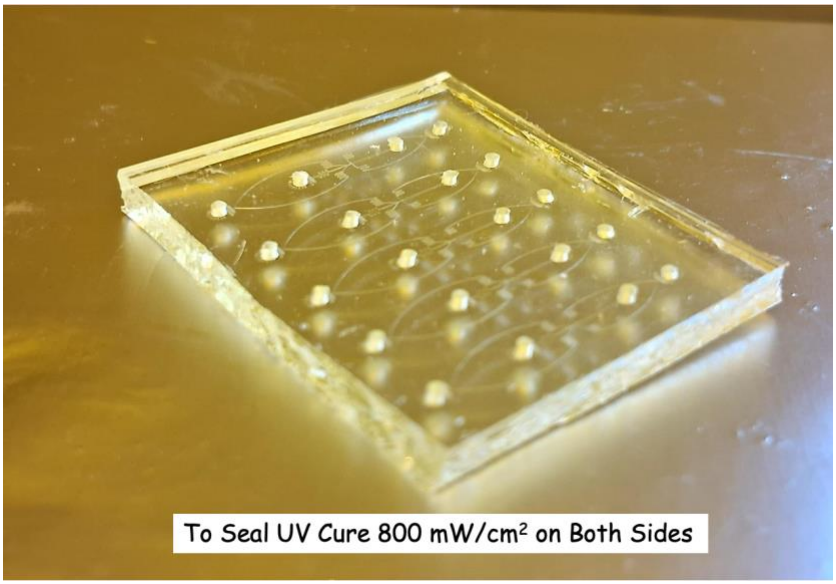
Visually check that both parts are joined together.



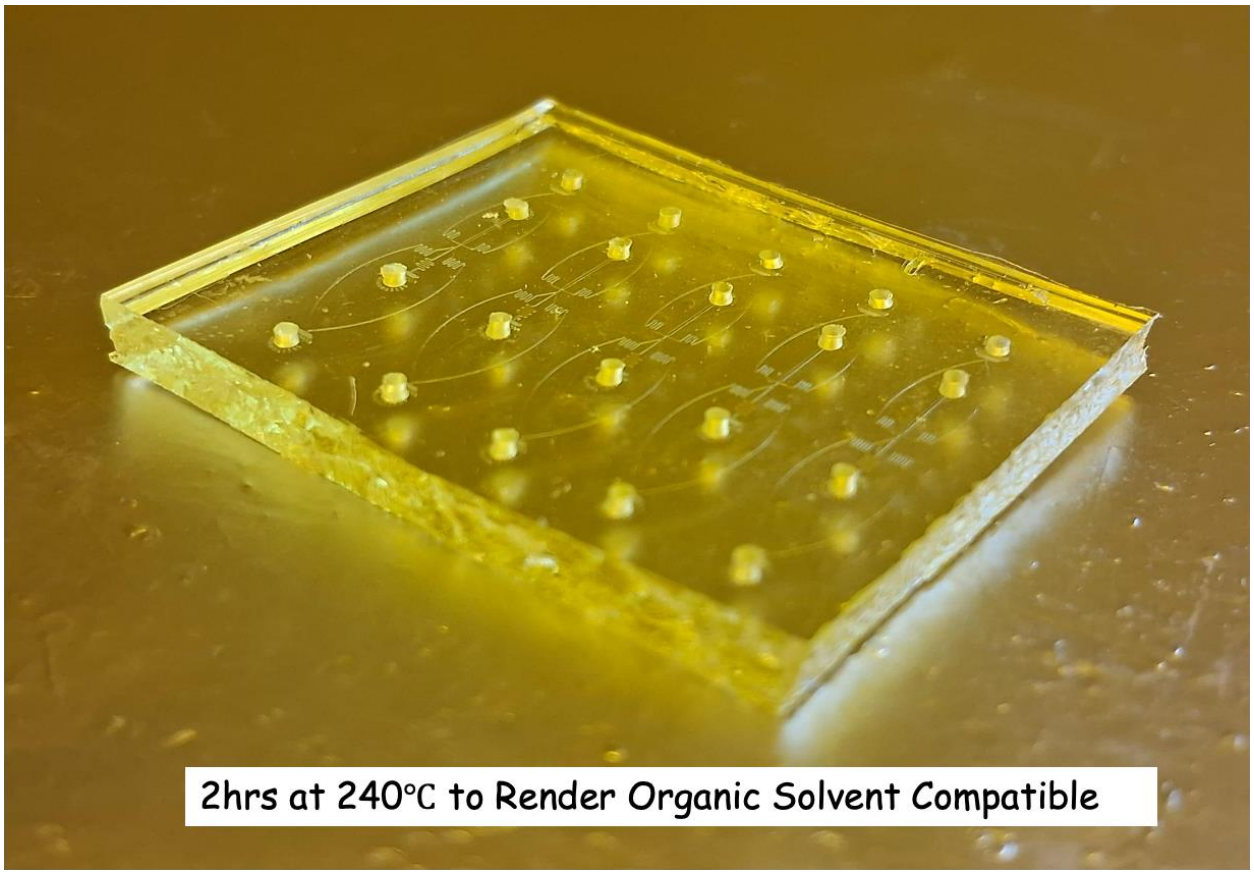
UV Cure for 800 mW/cm^2 on both sides to fully seal device.



Heat Treatment of Device:

To render the device organic solvent compatible, place in an oven and set the temperature to 240°C. Once the temperature is reached, bake for 2 hours. Switch off and allow oven to reach room temperature.

The device will have a slight change in color. It is compatible with all organic solvents and is 2 orders of magnitude stiffer than regular UV cured NOA 81.



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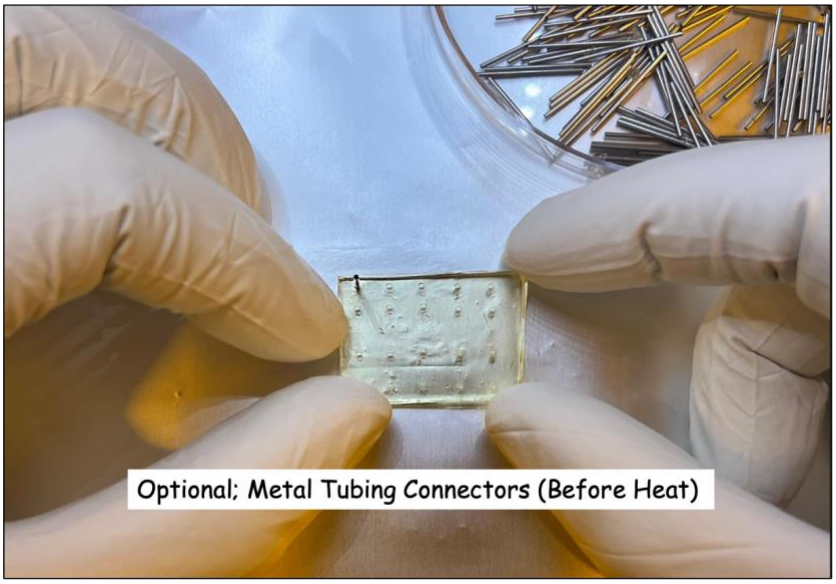
Optional: Metal Tubing Connectors

For high flow rate experiments it is recommended to add metal tubing connectors that attach to tubing. This will prevent leaking at the inlets.

It is recommended to add these connectors BEFORE the heat treatment, to help fit the connectors to the inlets.



Add all needles prior to heat treatment. (Note: This step can be optimized based on the tubing and connectors available in your lab). Seal needles with glue.

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Appendix

Link to Items in Apparatus:

1. Metal Connectors: https://www.amazon.com/Utoolmart-Industrial-Dispensing-Stainless-Applicator/dp/B08FM1TV16?th=1
2. Razor Blades: https://www.amazon.com/Bates-Single-Razor-Blades-Scraper/dp/B0CQVWK778/ref=sr_1_6?dib=eyJ2IjoiMSJ9.l_jBwpDCOkCCRUAcmZ4QBjrL_sCLvyGfnyv7RxYKbDNJOUlurEqw5nBlLXegXHYP5nMaRR_1erxB1Srv97xwomoxgXg35-U9Bv332wRGhgsgcJmwxytiTZTY2gYYhX0XjJyqfNQ99NyYFe5VnEmRtXeQSDiHcMJw0eHgtGu98n8QFJPtWob3bwySZgDCe8OeVDI6lgavkwAbCDKGHWqJkUgcj8ztj691kwt5igXUBTkcE7OhihYkloj1LQCoCDncSn_9-UNehGe_Fs4W8Q4-ihHIyK-o_mBY5JwicIKoT5Q.6j_J1I_sXtzm0G_xbWcQzLZGA3aPMLJpahAbAheM7ZA&dib_tag=se&keywords=razor%2Bblades%2Blarge%2Bpack&qid=1776046643&sr=8-6&th=1
3. NOA 81: https://norlandproducts.com/product/noa-81/
4. Scalpel: https://www.amazon.com/Disposable-Protective-Laboratory-Handle-Art-Cutting-Crafts/dp/B0BTYL2CLZ/ref=sr_1_4?crid=3RH7TW54DOX4S&dib=eyJ2IjoiMSJ9.TSrL8z2s4UT_lQ5soAtHnjpubFKSW8xij_rrQBKupyjNXvQE8gG83vIbmcMLOJXVhDq_HtawtWYctGIK4hJqVNcCWzw59ftZayDdS7LQ4gxGCYu-0UZRQouk3QY0FAxdV2t2TDiT9C5FXKVwl7xkRjqVHf43c7bxvARzh42Jaw101YT9SXfB7-k2WsU5OygVv8uI4PQ-uzUjxPur1fQV9rpwn6k-Hpn7rvxNncEwYUE.4dsFKRSkJ0v3kBEM_OZ9z0bStY_wPVtLDF9lYILx9aA&dib_tag=se&keywords=scalpel%2Bpointed&qid=1776046746&sprefix=scalpel%2Bpointe%2Caps%2C183&sr=8-4&th=1
5. PDMS: https://www.dow.com/en-us/pdp.sylgard-182-silicone-elastomer-kit.01064282z.html#overview

Petris Dish: https://www.amazon.com/Pioneer-Plastics-Plastic-Container-5-5625/dp/B08PC6MDT8?th=1

6. 1 mm Biopsy Pens: https://medexsupply.com/miltex-sterile-disposable-biopsy-punch-with-plunger-1mm-diameter-25-box-33-31aa-p-25/?sku=MTX-33-31AA-P/25&gad_source=1&gad_campaignid=14634096208&gbraid=0AAAADmq-DfbKqXIthFwICTOTzPoSuGmP&gclid=CjwKCAjwhe3OBhABEiwA6392zFk2iai904kbiFeHySRsRglv0AkRwpA7ng587MVzP872YSo8Q_WLzhoCKsUQAvD_BwE
7. 4" Glass Wafer (Soda-lime): https://order.universitywafer.com/default.aspx?cat=Soda%20lime%20Glass&diam=100mm