Protocol - Making Epoxies

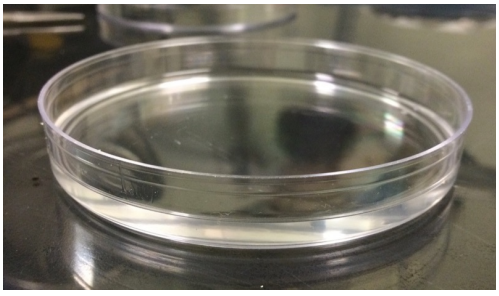
Jun Lab protocol for making epoxy molds from PDMS devices.

Materials

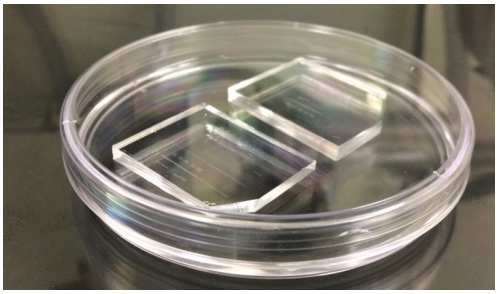
- PDMS monomer and crosslinker (Sylgard 184 Silicone Elastomer Kit)
- Loctite E-30CL Hysol epoxy (~1 tube for 10cm Petri dish epoxy)
- Epoxy dispenser gun
- 3M Static mixing tube
- Petri dish (choose size based on number of devices, 5cm = 1, 10cm = 4, 15cm = 12)
- Scotch tape
- Dremel tool (drill bit attachment and 1 1/2” plastic cutting wheel)
- Scalpel
- Vacuum chamber
- Level

Protocol

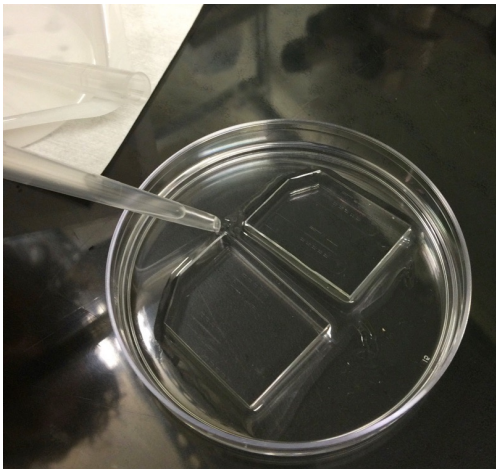
1. Pour 22g PDMS into the bottom half (smaller diameter) of a petri dish. Use a 10:1 monomer to cross-linker ratio (i.e., 22g monomer and 2g cross-linker). Bake overnight at 75C. This is the PDMS pad on which the devices will sit and the epoxy is poured over.
    - Bake the PDMS with the lid off, but otherwise keep the lid on at all times to avoid dust landing on the surface.
    - The 15cm petri dishes work well too. Use ~80g PDMS to cover the bottom dish.



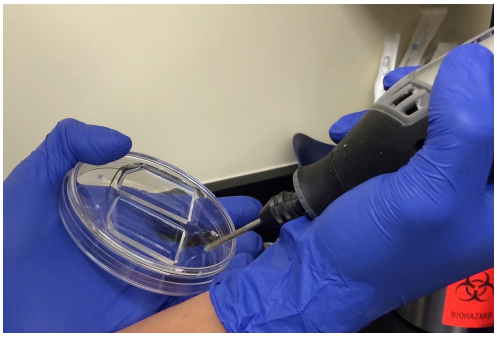
2. Clean desired template mother machine device(s) using Scotch tape to remove dust and particulates from the surface, trench, and channels, and place them feature side up on the hardened PDMS pad. You can also clean with EtOH and/ or using pressurized filtered air.
    - The devices you use to make the epoxy should be thin, because their thickness is the minimum thickness of devices coming from the final epoxy. If the device is thin it will also be easier to remove the PDMS from the epoxy after hardening.
    - Bake the template devices for at least 12 hours to insure they are totally solidified.
    - Do not treat devices with pentane/ acetone. This may make the epoxy stick to the devices.
    - The sides of the PDMS devices should be as smooth as possible. Use a sharp razor blade and the guillotine method. You can also cut them at a slight angle such that they have a large base agains the pad.
    - Clean the surface of the PDMS pad in the petri dish in a similar fashion if it is dirty.

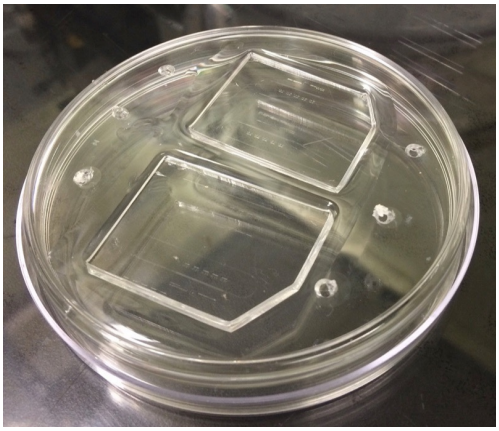


3. Mix up some more PDMS and use a pipet to create a small seal between the devices and the pad. Be careful not to get any on the surface of the devices. Bake again to harden the seal. You do this so epoxy does not get under the devices and to soften the corners.

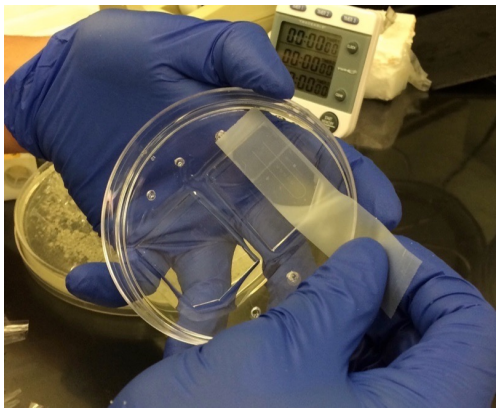


4. After the PDMS has hardened, drill some some holes into the plastic bottom of the petri dish, careful not to pierce the PDMS. This will help when degassing the PDMS.
    - Put some holes directly beneath the devices, unlike the picture.



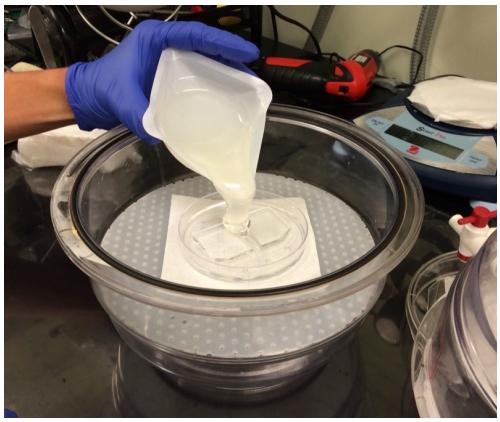


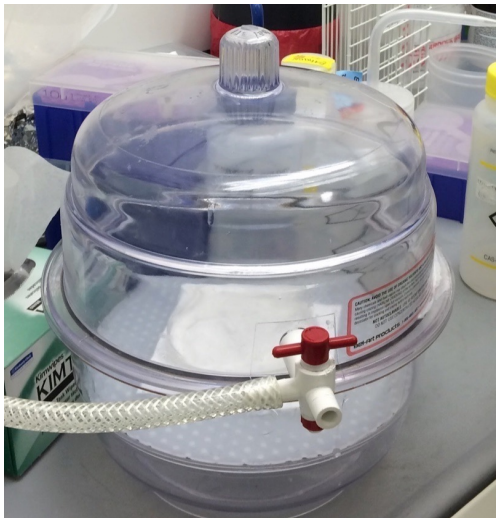
5. Prepare to pour the epoxy. First clean the PDMS template again.
    - You can also clean it with ethanol and the air hose. Inspect it under the stereoscope to insure that it is clean.



6. Put the PDMS template in a vacuum and degas it. The longer the better, at least 20min. By getting the air out now, there is less to produce bubbles while the epoxy degasses.

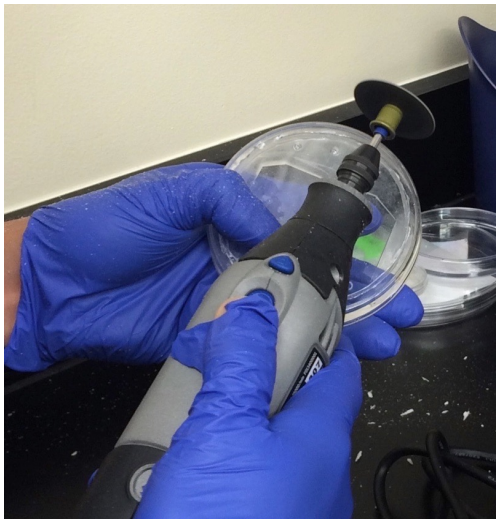
7. Right before you are ready to pour, mix the epoxy together in a weigh dish. Immediately and quickly open the vacuum chamber and pour the epoxy onto the PDMS template. Put the epoxy/ template back in the vacuum. Degas for 10min (the epoxy pot time is 30min).
    - You want to get rid as many bubble as possible, but you also don't want any bubbles to harden near the features of the device.
    - The 10 minute time frame is important. Degassing longer increases the risk that there will be rough spots at the surface caused by tiny bubbles that harden.
    - You do not have to use the entirety of the epoxy. Just make sure the device surfaces are covered. The less epoxy, the less bubbles there will be.
    - Don't use a super powerful vacuum for this step or the epoxy will boil.



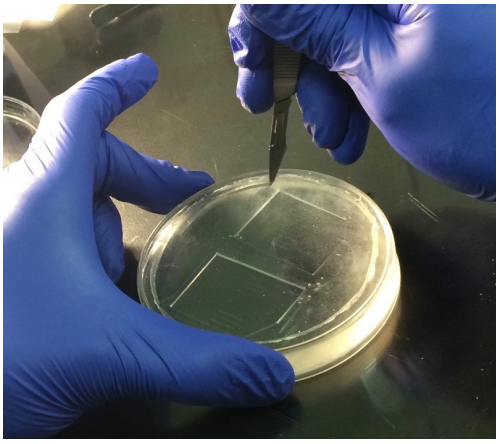


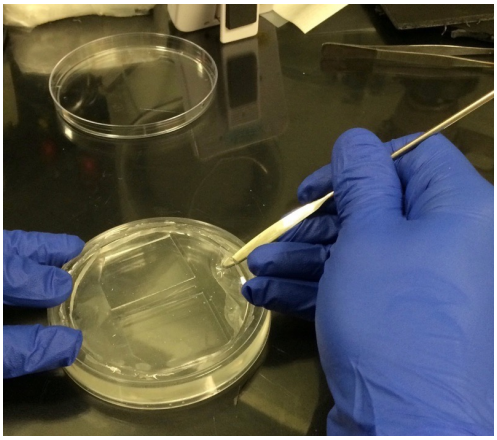
8. Let the epoxy sit for at least 24hrs on a level surface. It may be a little hazy but that should clear up.

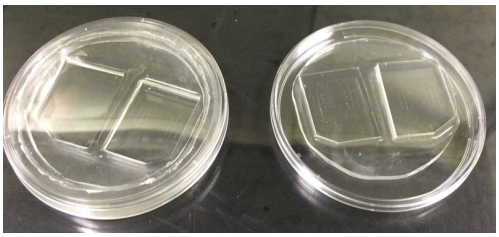
9. Use a Dremel tool with plastic cutting wheel attachment to remove the plastic bottom of the petri dish. Be sure to wear eye protection, and cut carefully around the perimeter of the dish, away from the devices and only so deep as to completely separate the plastic bottom from the walls of the dish. You need not cut the PDMS layer underneath.
    - You can also use a grinder to remove the edge of the plastic bottom.



10. Use a scalpel to cut out the PDMS slab, following the same path as the Dremel tool. The slab should lift out cleanly from the layer underneath, leaving a relief of the features of the device cast in the hardened epoxy below.
    - As you begin to peel up the PDMS pad, squirting some ethanol between the two surfaces will help release the PDMS.







11. Cure the epoxy again, this time with no PDMS. Leave it at 40-60C for another 24 hours.

12. Label the back side of the epoxy, clean the surface and features of the device, and store with a lid (the top of the Petri dish!). It is ready to use.
    - When casting the first several devices, it is better to use a lower temperature to cure the PDMS (~60C). Using higher temperatures can cause the epoxy and PDMS to form a bond.