Circuit making SOP Updated 3/26/2024

Related files: BOM (tools and materials), manufacturing overview video, laser cutting files, open access journal paper related (citation and URL go HERE)

Note: This SOP and related BOM are for making stretchable circuits using VHB as the circuit substrate and rubber cement as the encapsulant. To make circuits with DS10 (SmoothOn Inc., [link](https://www.smooth-on.com/products/dragon-skin-10-medium/)), or a DS10/Slacker variation (SmoothOn Inc., link), cast a 0.5 mm thick layer of DS10/DS10+Slacker as the substrate, and use DS10/DS10+Slacker to encapsulate. The only other difference is to use this craft tape with a slight adhesive (Super sun/Amazon, [link](https://www.amazon.com/gp/product/B08HM5LX6L/ref=ppx_yo_dt_b_search_asin_title?ie=UTF8&psc=1)) instead of sticker paper if using plain DS10 as the substrate. The sticker paper in the BOM should work with a tackified DS10+Slacker combination.

Safety note: Wear a lab coat, nitrile gloves, safety glasses, and other relevant PPE while completing this procedure. Practice good lab safety.

Processes overview:

1. Making OGaIn—method and materials needed in journal paper
2. Harvesting Pro Mini Components (if necessary)
3. Making circuit starter
4. Completing soft circuit

Making OGaIn:

1. From paper (Methods section)

Harvesting:

1. Turn hot plate to 300 C
2. Place Pro Mini in weight boat, and place on hot plate
3. Using blunt tweezers in non-dominant hand, apply light, downward force to circuit
4. After approximately 60 seconds to 1 minute, when solder is melted, use finer tweezers in your right hand to remove components and place in second aluminum weigh boat, off of hot plate
   1. To test if solder is melted, try removing a component
   2. Keep applying downward force, so as to not lift whole PCB while removing component
5. 15 components should have been removed for the Pro Mini
6. Once removed, turn off hot plate and transfer components to a safe storage location/closed tin

Making circuit starter:

1. Cut a strip of VHB at least 3 inches in length
2. Cut a strip of sticker paper tape at least 6 inches in length, and remove the tape to obtain just the paper
3. On the sticky side of the VHB, place a three-inch segment of the sticker paper (aligned)
4. Remove the red VHB plastic, and put sticker paper on the other side of the VHB. The result will be VHB sandwiched between sticker paper.
5. To ensure good adhesion, use the edge of a piece of acrylic or something similarly hard, and scrape it across either side of the sandwich.
6. Place the sandwiched VHB in the ULS laser cutter, and cut the ULS board outline and VIAs/header pin holes. The ULS laser settings for this are 100% power, 20% speed, 1000 ppi, with a thickness of approx. 0.31 inches.
7. Warm up the LPKF laser
8. In LPKF laser bed, tape down a piece of copy paper.
9. Cut the LPKF\_Paper.cp2d design into this paper. It should be the circuit outline. This makes it so the top and bottom traces will align.
10. Remove the section of paper that was cut out.
11. Place the sandwiched VHB that’s been cut to size and VIAs engraved into the slot in the paper, and tape down with painter’s tape.
12. Cut the LPKF\_top.cp2d design (the top traces of your circuit). Use precision tweezers to make sure the cuts went through the sticker paper.
13. Flip the circuit upside down (such that the bottom traces will cut correctly), align it in the paper cutout, and cut the LPKF\_Bottom.cp2d traces file.
14. You should now have VHB with sticker paper on both faces that have top and bottom layer traces cut into them.

Completing soft circuit:

1. Laser cut a piece of acrylic to be notably larger than the chosen circuit, such that the circuit starter can be taped with painter’s tape to the acrylic as a back.
2. Starting with the bottom traces/side, use precision tweezers to remove the sticker paper where the traces are (leaving only the pathways where you want conductive material to be).
3. Get a small amount of OGaIn on the Fluke multimeter probe tip, and poke it into the VIAs/header pin holes. Take your time here, as these electrical connections are vital.
4. Once filled, use a paintbrush to spread OGaIn onto where the traces are. Use a swirling motion to ensure the material gets down to the material. If you think any sections aren’t filled, feel free to use the multimeter probe to put any material in a specific place.
5. Lightly scrape off extra OGaIn with a small piece of acrylic (lightly drag over circuit surface).
6. Use tweezers with good grip to remove the mask.
7. Use the Fluke multimeter to test that each of the bottom traces works, and aren’t shorted with neighboring traces. If two traces are connected, dip a clean multimeter probe tip into simple green, and firmly drag across the area where the bridge is to separate the traces. If a trace is not conductive, use the probes to determine where the break is, and then use the probes to dab a little bit of OGaIn to connect the trace.
8. Load rubber cement into a 10 mL syringe with an 18 Ga needle, and extrude rubber cement over the traces to encapsulate. Let cure at least 15 minutes.
9. Flip circuit over such that top side is facing up on the piece of acrylic, and stick down with painter’s tape again.
10. Repeat steps 2, 4, 5, 6, and 7 above on the top side.
11. Use precision tweezers to place the circuit components in the correct orientations, sticking them down onto the VHB or other circuit substrate.
12. Use wire strippers to cut 4mm of insulation off one end of an approximately three inch wire, and 1-2mm off the other end.
13. To the end with 4mm exposed, crimp on a header pin connector
14. Next to where your external connection traces terminate, extrude a dab of SilPoxy out of a 10 mL syringe.
15. Use tweezers to place the 1-2mm exposed end of the wire onto the end of the OGaIn trace where you want an off-board connection. Tap the sheath of the wire into the spot of Silpoxy.
16. Once all are placed, use the syringe of Silpoxy to dab more Silpoxy over the still damp bottom silpoxy such that the Silpoxy surrounds the sheath of the wire near the connection site.
17. Let cure at least 10 min (but note that Silpoxy has a 24h cure time).
18. Test circuit functionality.
19. Repeat step 8 above, covering the circuit components as well. Let cure at least 30 minutes.
20. Use syringe with Silpoxy to extrude a small layer of silpoxy over the microprocessor legs.
21. Let cure 24h.