

Microcontact Printing Procedures for Adhesive and Conductive Epoxies

This objective was accomplished through a formal record of the procedures to deliver a stamped product which met the benchmark mechanical, optical, and electrical criteria. By following a thorough optimization and verification process, as stated in the prior methodology, written procedure was developed for each of the substrate and ink combinations tested.

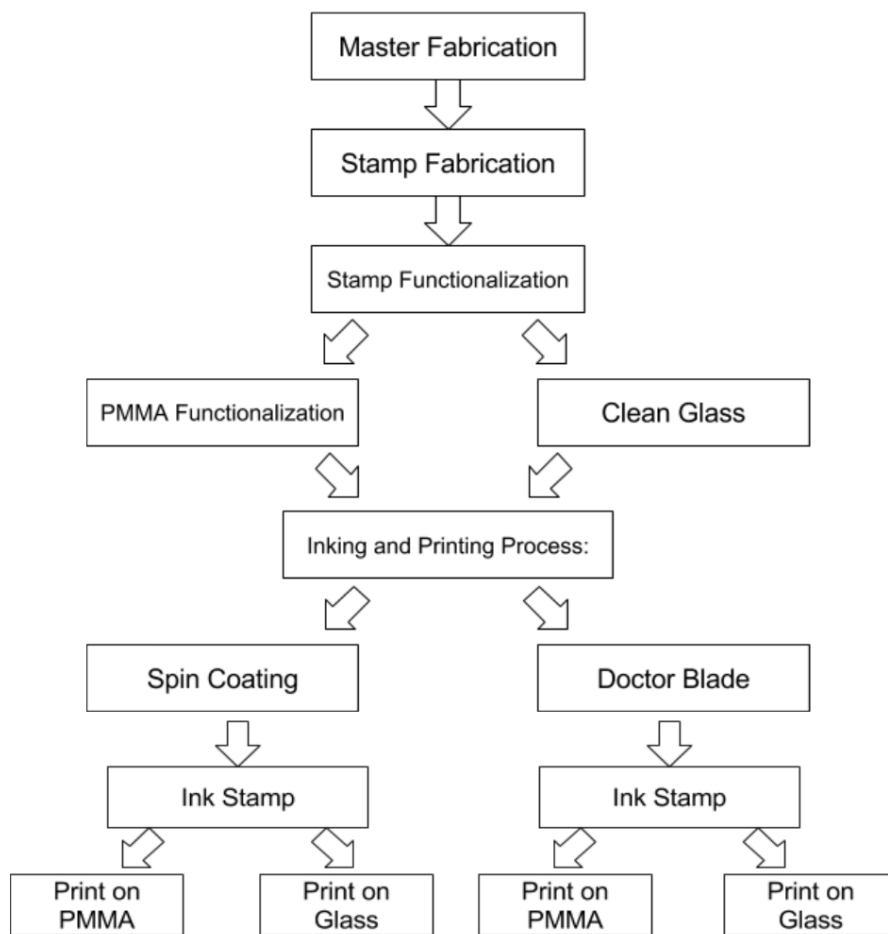


Figure 4-1: Flowchart of Deliverable

4.1 Procedure Combinations

Procedures for the following combinations are outlined below:

1. Non-conductive epoxy on PMMA substrate
2. Conductive epoxy on PMMA substrate
3. Non-conductive epoxy on glass substrate
4. Conductive epoxy on glass substrate

4.2 Initial Procedure Steps

In each procedure provided, master preparation, stamp fabrication, and stamp functionalization will occur. These steps are as follows in Table 4-1:

Table 4-1: Initial Procedure Steps

1. Master Fabrication	A pre-fabricated master is given and used to fabricate the stamp
2. Stamp Fabrication	Prepare PDMS <ul style="list-style-type: none"> ● Mix PDMS (Sylgard 184) with a 10:1 (resin: hardener) in the speed mixer for 30 s at 1000 rpm and 120 s at 2000 rpm ● Fill syringes with 3-4 ml of PDMS with the black tip ● Store syringes in the freezer overnight
	Mold-Tool Treatment <ul style="list-style-type: none"> ● Clean the aluminum housing of the master first with acetone and then isopropanol to remove dirt on the surface
	Silanization of the Mold-Tool <ul style="list-style-type: none"> ● Place the mold tool in a desiccator for 30 min at 0.2 bar with two drops of (Tridecafluoro-1,1,2,2-tetrahydroctyl) trichlorosilane 97%
	Molding Process <ul style="list-style-type: none"> ● Close the mold-tool, and gently tighten the screws ● Mount the red tip on the syringe (filled with PDMS) and push excessive air out of the syringe ● Insert the syringe into the mold-tool and slowly inject PDMS until full
	Curing Process <ul style="list-style-type: none"> ● Leave the syringe in the tool during polymerization ● Place the master with the attached syringe in the oven for 12 h @ 60 C

	<p>Mold Removal</p> <ul style="list-style-type: none"> ● Remove the mold and let cool to room temperature ● Once cooled, remove the stamp from the mold-tool ● Place the stamp onto a microscope slide and store in a dry, clean place ● Fabricate stamps until the lateral dimensions of the pattern are comparable to the master
<p>3. Stamp Functionalization</p>	<p>Oxygen Plasma Treatment in Barrel Asher</p> <ul style="list-style-type: none"> ● Perform Recipe 1: Cleaning <ul style="list-style-type: none"> ○ The specifications of this treatment include an oxygen flow of 300 sccm, power of 1000 W, and a time duration of 300 seconds. ● Perform Recipe 6: Surface Activation <ul style="list-style-type: none"> ○ The specifications of this treatment include an oxygen flow of 50 sccm, power of 1000 W, and a time duration of 20 seconds.

4.3 Procedure One: PMMA and EPO-TEK 302-3M

Table 4-2: Procedure One

Time Constraints	<p>Stamp:</p> <ul style="list-style-type: none"> • Use the stamp for printing within 80 min of functionalization <p>Epoxy:</p> <ul style="list-style-type: none"> • Spin coat the epoxy within 15 min of mixing • Print with the epoxy within 60 min of mixing
Surface Preparation	<p>Silicon Wafer Cleaning:</p> <ul style="list-style-type: none"> • Place silicon wafer into glass container filled with acetone • Place glass container into a sonicator and wait for 10 min • Remove silicon wafer from the container and clean with isopropanol • Dry the silicon wafer with nitrogen • Place silicon wafer onto hot plate at 100 °C for 3 min
Ink Pad Creation	<p>Steps to Create Ink Pad:</p> <ul style="list-style-type: none"> • Speed Mixer: Program 1 • Spin Coat Settings: Program 4
Stamp Inking	<p>LabVIEW Settings:</p> <ul style="list-style-type: none"> • Distance: 24.55mm • Force: 0.4 N, Time: 20 s
Stamp Printing	<p>LabVIEW Settings:</p> <ul style="list-style-type: none"> • Distance: 23mm • Step1: Force: 0.2 N, Time: 20 s • Step2: Force: 0.1 N, Time: 20 s
Stamp Cleaning	<p>Steps to Clean Stamp:</p> <ul style="list-style-type: none"> • Spray ethanol on the stamp • Use nitrogen gas to dry the stamp
Adhesive Curing	<p>Two Options for Curing:</p> <p>Room Temperature</p> <ul style="list-style-type: none"> • Time: overnight <p>Oven:</p> <ul style="list-style-type: none"> • Temperature: 65°C • Time: 3 hours

4.4 Procedure Two: PMMA and EPO-TEK H20E-PFC

Table 4-3: Procedure Two

Time Constraints	<p>Stamp:</p> <ul style="list-style-type: none"> • Print with the stamp within 80 min of Functionalization <p>Epoxy:</p> <ul style="list-style-type: none"> • Print with the epoxy within 3 days of mixing
Surface Preparation	<p>Glass Plate Cleaning:</p> <ul style="list-style-type: none"> • Clean glass surface with acetone and isopropanol
Prepare Ink Pad	<p>Speed Mixer:</p> <ul style="list-style-type: none"> • Program 2 <p>Doctor Blade Settings:</p> <ul style="list-style-type: none"> • Set micrometer screw to 18 μm • Apply 2 - 2.5 mL of EPO-TEK H20E-PFC to substrate surface at the width of the desired ink pad
Ink Stamp	<p>LabVIEW Settings:</p> <ul style="list-style-type: none"> • Distance: 23 mm • Force: 0.85 N, Time: 20 s
Print with Stamp	<p>LabVIEW Settings:</p> <ul style="list-style-type: none"> • Distance: 23mm • Step 1: Force: 0.85 N, Time: 20 s • Step 2: Force: 0.65 N, Time: 20 s
Clean Stamp	<p>Steps to Clean Stamp</p> <ul style="list-style-type: none"> • Spray ethanol on the stamp • Clean the stamp with tissue • Put the stamp into the sonication for one minute • Dry the stamp with nitrogen gas
Adhesive Curing	<p>Oven:</p> <ul style="list-style-type: none"> • Temperature: 80°C • Time: 3 hours

4.5 Procedure Three: Glass and EPO-TEK 302-3M

Table 4-4: Procedure Three

Time Constraints	<p>Stamp:</p> <ul style="list-style-type: none"> ● Print with the stamp within 80 min of functionalization <p>Epoxy:</p> <ul style="list-style-type: none"> ● Spin coat with the epoxy within 15 min of mixing ● Print with the epoxy within 60 min of mixing
Surface Preparation	<p>Glass Substrate Cleaning:</p> <ul style="list-style-type: none"> ● Clean the substrate by sonication in water with soap for 10 minutes at 100% power ● Dip the substrate in HNO₃ at 20°C for 5 minutes ● Rinse the substrate with water ● Dip the substrate in HNO₃ at 100°C for 5 minutes ● Rinse the substrate with water ● Use nitrogen and spin dryer to remove water from the surface ● Put glass substrate into the container <p>Silicon Wafer Cleaning:</p> <ul style="list-style-type: none"> ● Place silicon wafer into glass container filled with acetone ● Place glass container into a sonicator and wait for 10 min ● Remove silicon wafer from the container and clean with isopropanol ● Dry the silicon wafer with nitrogen ● Place silicon wafer onto hot plate at 100 °C for 3 min
Prepare Ink Pad	<p>Speed Mixer:</p> <ul style="list-style-type: none"> ● Program 1 <p>Spin Coat Settings:</p> <ul style="list-style-type: none"> ● Program 4
Ink Stamp	<p>LabVIEW Settings:</p> <ul style="list-style-type: none"> ● Force: 0.4 N, Time: 20 s, ● Distance for silicon wafer: 23 mm
Print with Stamp	<p>LabVIEW Settings:</p> <ul style="list-style-type: none"> ● Distance: 24.55mm ● Step 1: Force: 0.2 N, Time: 20 s ● Step 2: Force: 0.1 N, Time: 20 s
Clean Stamp	<p>Steps to Clean Stamp</p> <ul style="list-style-type: none"> ● Spray ethanol on the stamp ● Use nitrogen gas to dry the stamp
Adhesive Curing	<p>Room Temperature</p> <ul style="list-style-type: none"> ● Time: Overnight <p><i>or</i></p> <p>Oven:</p> <ul style="list-style-type: none"> ● Temperature: 65°C ● Time: 3 hours

4.6 Procedure Four: Glass and EPO-TEK H20E-PFC

Table 4-5: Procedure Four

Time Constraints	<p>Stamp:</p> <ul style="list-style-type: none"> Print with stamp within 80 min of functionalization <p>Epoxy:</p> <ul style="list-style-type: none"> Print with epoxy within 3 days of mixing
Surface Preparation	<p>Glass Substrate Cleaning:</p> <ul style="list-style-type: none"> Clean the substrate by sonication in water with soap for 10 minutes at 100% power Dip the substrate in HNO₃ at 20°C for 5 minutes Rinse the substrate with water Dip the substrate in HNO₃ at 100°C for 5 minutes Rinse the substrate with water Use nitrogen and spin dryer to remove water from the surface Put glass substrate into the container <p>Glass Plate Cleaning:</p> <ul style="list-style-type: none"> Clean glass surface with acetone and isopropanol
Prepare Ink Pad	<p>Speed Mixer:</p> <ul style="list-style-type: none"> Program 2 <p>Doctor Blade Settings:</p> <ul style="list-style-type: none"> Set micrometer screw to 18 μm Apply 2 - 2.5 mL of EPO-TEK H20E-PFC to substrate surface at the width of the desired ink pad
Ink Stamp	<p>LabVIEW Settings:</p> <ul style="list-style-type: none"> Distance: 23 mm Force: 0.85 N, Time: 20s
Print with Stamp	<p>LabVIEW Settings:</p> <ul style="list-style-type: none"> Distance: 24.55mm Step 1: Force: 0.65 N, Time: 20 s Step 2: Force: 0.45 N, Time: 20 s
Clean Stamp	<p>Steps to Clean Stamp</p> <ul style="list-style-type: none"> Spray ethanol on the stamp Clean the stamp with tissue Put the stamp into the sonication for one minute Dry the stamp with nitrogen gas
Adhesive Curing	<p>Oven:</p> <ul style="list-style-type: none"> Temperature: 120°C Time: 15 minutes <p><i>or</i></p> <ul style="list-style-type: none"> Temperature: 80°C Time: 3 hours