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Priming Methods for PDMS Devices Study Report

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Keywords

PDMS, Priming, Microfluidics

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Priming Methods for PDMS Devices Study Report

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Critical Factors

- Priming the device soon after plasma bonding (within 3 hours) yields better results
- Of the methods tested, fully submerging the device inside a vacuum chamber for 20 minutes yielded the best results.

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Goal

Test various priming methods for PDMS microfluidic devices. Priming is the step taken to fill the channels of the device prior to use. Ideally, the priming method will uniformly fill the channels with the desired media with little to no bubbles.

Materials

- Previously made SU-8 mask of device with complex channel configurations
- PDMS/PDMS Curing Agent
- Metal inlets for device
- Deionized Water
- Food Coloring (green)
- Isopropyl Alcohol

Equipment

- Technics O2 Plasma Chamber
- Vacuum Chamber
- Vacuum Pump
- Syringe
- Celestron Cosmos 5MP LCD Desktop Digital Microscope

Protocols

Six different priming methods were selected for testing in this study:

1. Direct syringe injection (control)
2. Direct syringe vacuum
3. One inlet submerged with vacuum chamber
4. Fully submerged with vacuum chamber
5. Fully submerged in degassed medium with vacuum chamber
6. Alcohol priming followed by direct syringe injection

Furthermore, each priming method was tested within 3 hours of plasma bonding of the PDMS to a glass slide and more than 3 hours after plasma bonding—resulting in a total of 12 different test conditions. Typically the priming methods were tested approximately 1 hour after plasma bonding and approximately 24 hours after plasma bonding to satisfy the two criteria.

Direct Syringe Injection (control)

1. Fill a syringe with a few milliliters of green food coloring
2. Insert the syringe tip into the inlet of the device
3. Inject food coloring into the device until a bead of food coloring forms at the outlet
4. Carefully remove syringe from device

Direct Syringe Vacuum

1. Mix deionized water with a large amount of green food coloring in a small plastic cup for sufficient volume to cover one inlet of the microfluidic device but not the other if it is placed vertically in the cup
 - a. It is important to use a significant quantity of food coloring when mixing with deionized water as it is difficult to visualize filled channels/bubbles without sufficient food coloring
2. Insert the syringe tip into the outlet of the device
3. Submerge the inlet of the device
4. Ensuring the inlet remains submerged, carefully pull the syringe plunger to suction the medium through the device until some medium can be seen inside the syringe
5. Carefully remove the syringe from the device

One Inlet Submerged with Vacuum Chamber

1. Mix deionized water with a large amount of green food coloring in a small plastic cup for sufficient volume to cover one inlet of the microfluidic device but not the other if it is placed vertically in the cup
 - a. It is important to use a significant quantity of food coloring when mixing with deionized water as it is difficult to visualize filled channels/bubbles without sufficient food coloring
2. Insert a metal inlet into one of the inlets of the device
3. Place the device into the small plastic cup ensuring that the metal inlet is fully submerged and the outlet is not submerged
4. Place everything inside a vacuum chamber
5. Turn on the vacuum pump
6. Allow the vacuum to be run for 20 minutes

Fully submerged with Vacuum Chamber

1. Insert a metal inlet into both the inlet and outlet of the device
2. Mix deionized water with a large amount of green food coloring in a shallow metal pan for sufficient volume to cover both the inlet and outlet of the microfluidic device
 - a. It is important to use a significant quantity of food coloring when mixing with deionized water as it is difficult to visualize filled channels/bubbles without sufficient food coloring
3. Completely submerge the device in the water/food coloring
4. Place everything inside the vacuum chamber
5. Turn on the vacuum pump
6. Allow the vacuum to be run for 20 minutes

Fully Submerged in Degassed Medium with Vacuum Chamber

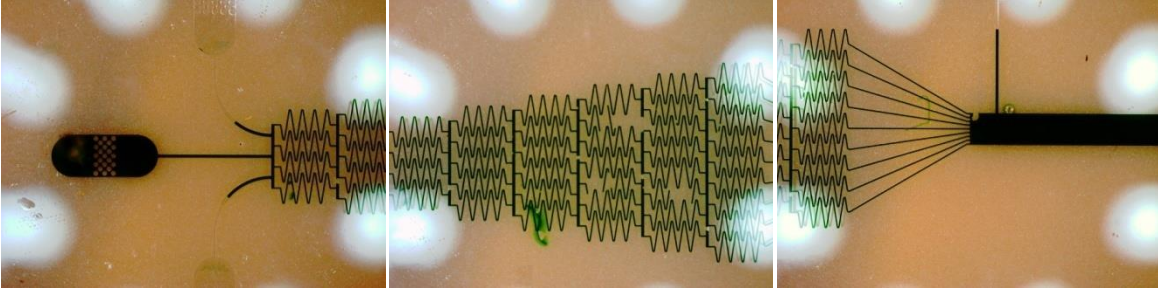
1. Insert a metal inlet into both the inlet and outlet of the device
2. Mix deionized water with a large amount of green food coloring in a shallow metal pan for sufficient volume to cover both the inlet and outlet of the microfluidic device
 - a. It is important to use a significant quantity of food coloring when mixing with deionized water as it is difficult to visualize filled channels/bubbles without sufficient food coloring
3. Place the shallow metal pan with medium into the vacuum chamber and vacuum it for 30 minutes.
4. Completely submerge the device in the water/food coloring
5. Place everything inside the vacuum chamber
6. Turn on the vacuum pump
7. Allow the vacuum to be run for 20 minutes

Alcohol Priming Followed by Direct Syringe Injection

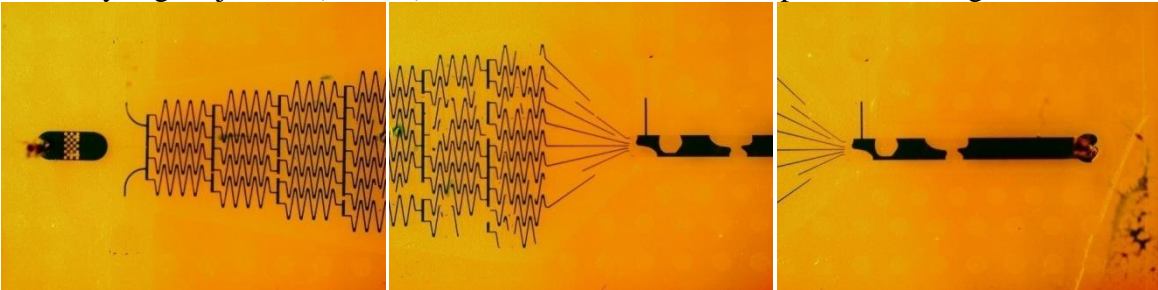
1. Fill a syringe with a few milliliters of isopropyl alcohol
2. Insert the syringe tip into the inlet of the device
3. Inject alcohol into the device until a bead forms at the outlet
4. Carefully remove syringe from device
5. Empty the syringe and fill with a few milliliters of green food coloring
6. Insert the syringe tip into the inlet of the device
7. Inject food coloring into the device until a bead of food coloring forms at the outlet
8. Carefully remove syringe from device

Results

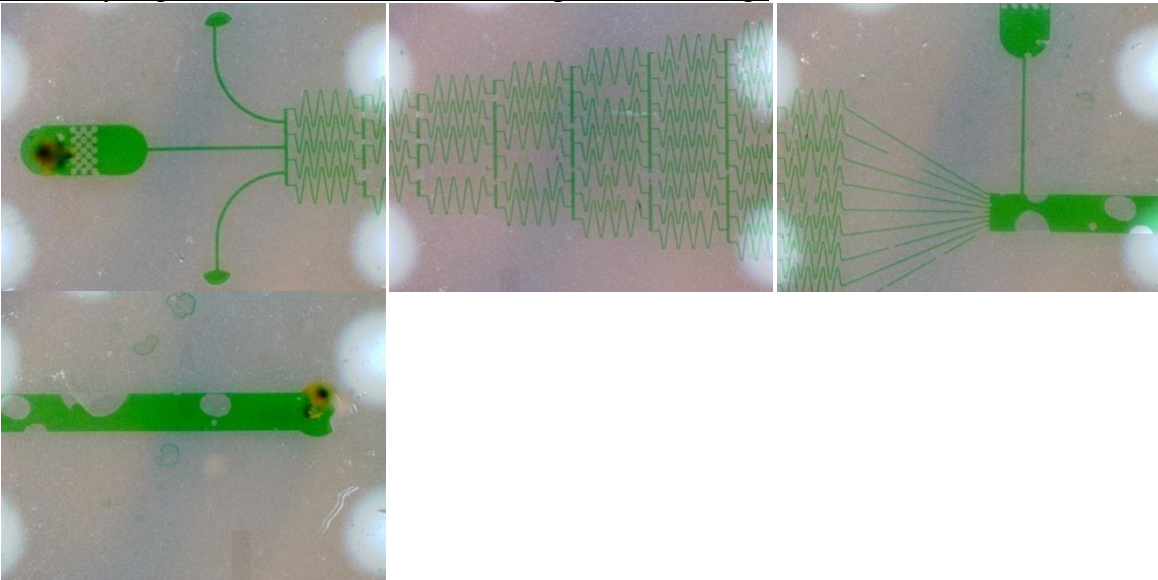
Direct Syringe Injection (control) [Within 3 hours of plasma bonding]



Direct Syringe Injection (control) [Greater than 3 hours after plasma bonding]



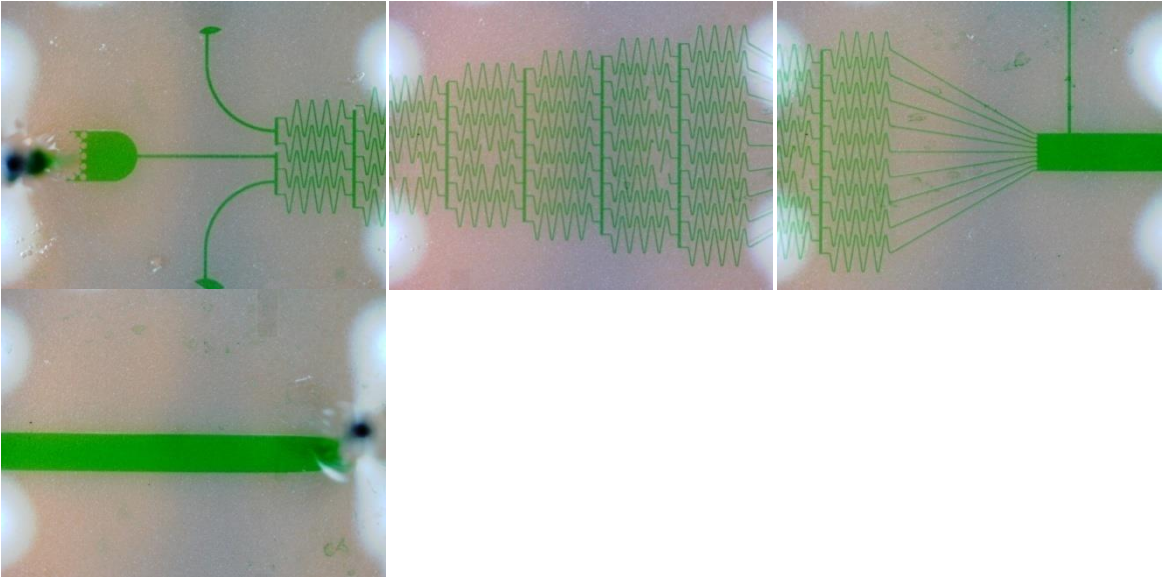
Direct Syringe Vacuum [Within 3 hours of plasma bonding]



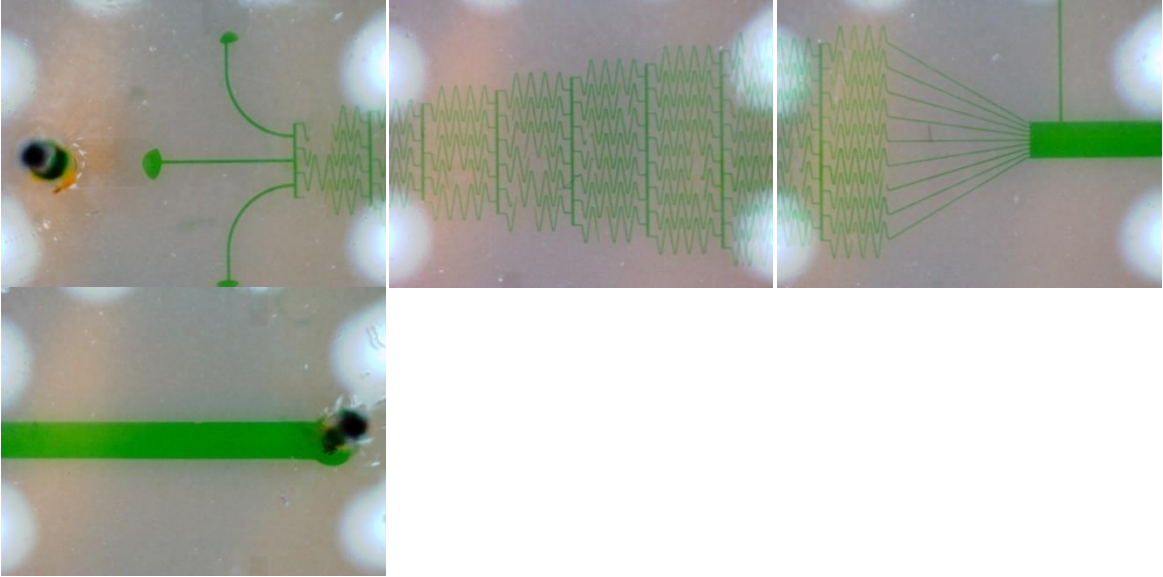
One Inlet Submerged with Vacuum Chamber

No filling of the channels was observed and no pictures were taken.

Fully submerged with Vacuum Chamber [Within 3 hours of plasma bonding]

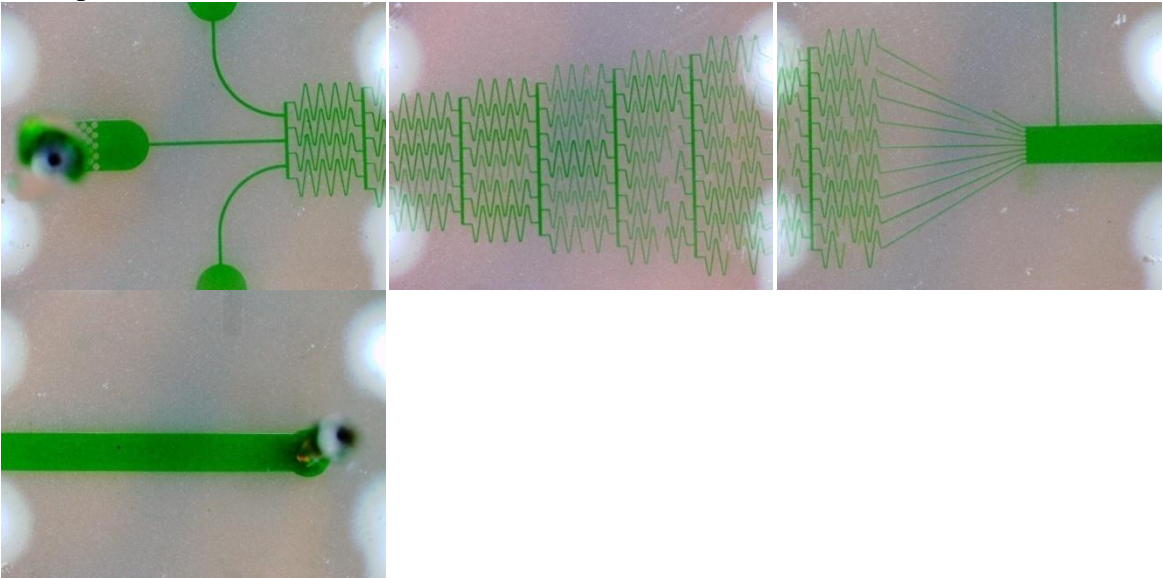


Fully submerged with Vacuum Chamber [Greater than 3 hours after plasma bonding]

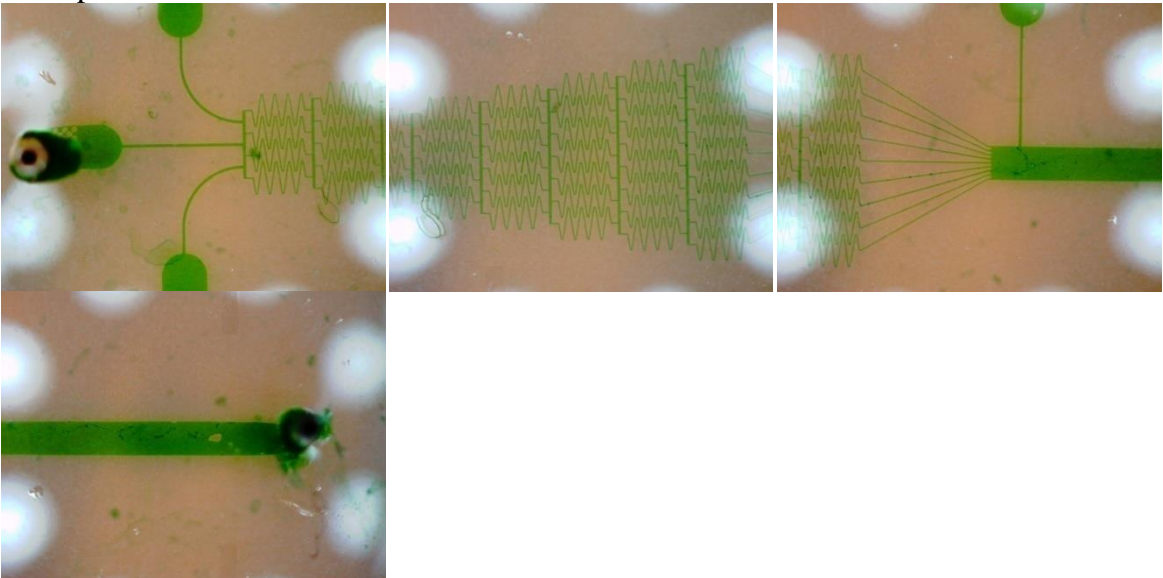


Fully Submerged in Degassed Medium with Vacuum Chamber [Within 3 hours of plasma bonding]

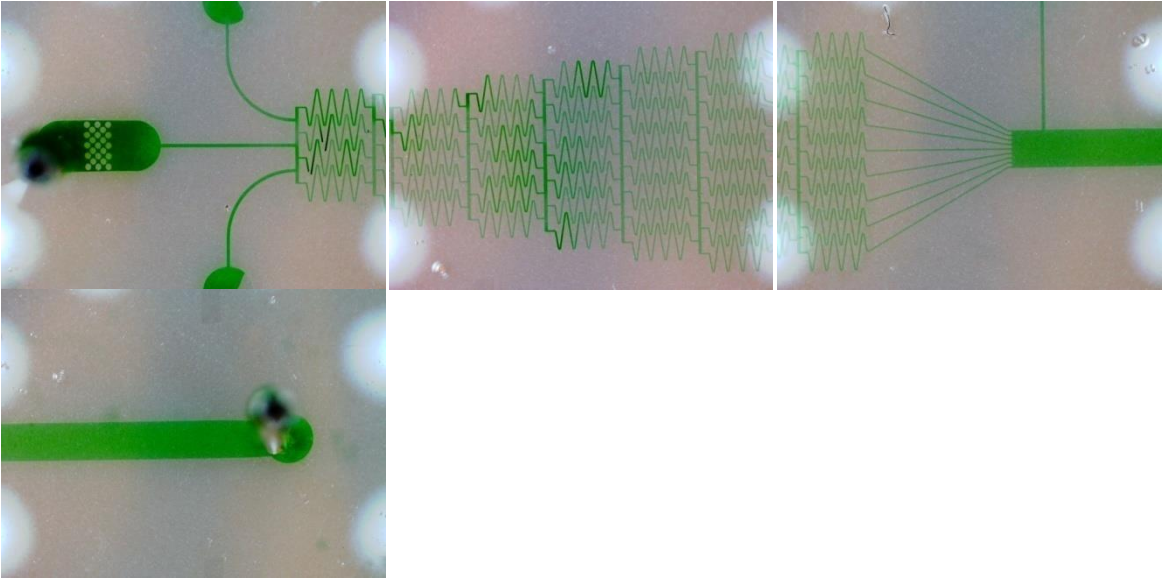
Attempt 1:



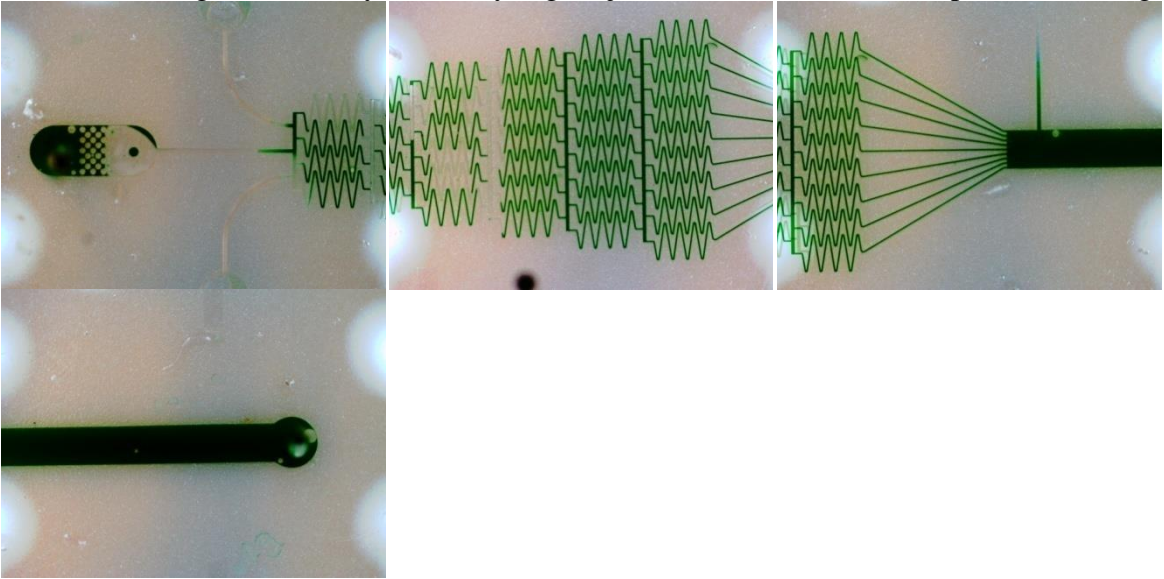
Attempt 2:



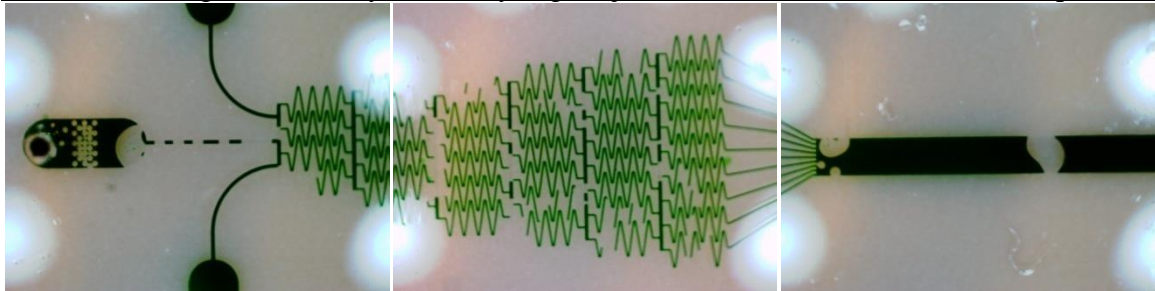
Fully Submerged in Degassed Medium with Vacuum Chamber [Greater than 3 hours after plasma bonding]



Alcohol Priming Followed by Direct Syringe Injection [Within 3 hours of plasma bonding]



Alcohol Priming Followed by Direct Syringe Injection [Greater than 3 hours after plasma bonding]



Discussion

The overall goal of priming the devices was to properly fill all the channels and to minimize the number of bubbles formed. The layout of the device was chosen because it has two distinct sections: one in which there are many small channels in a complex, parallel pattern and another of a straight and wide channel. The wide channel should have been relatively easy to fill whereas the many small channels would create problems with being filled at different rates and trapping pockets of air.

Looking at the results for direct syringe injection and alcohol priming followed by direct syringe injection, there are obvious differences between the devices primed within 3 hours of plasma bonding and those that were not. In devices primed at greater than 3 hours after plasma bonding for those two priming methods, large bubbles formed in the wide channels. This illustrates the fact that the oxygen plasma used in bonding causes the channels to be hydrophilic and more amenable to be filled with polar solvents such as water. This hydrophilic effect disappears over time as the PDMS reverts back to its naturally hydrophobic state. A similar result can be seen in direct syringe vacuum even within 3 hours of plasma bonding and so further testing for greater than 3 hours after plasma bonding was not conducted. The direct syringe methods all generally had difficulties with properly filling the small channels.

The fully submerged methods proved to be the best with little differentiation between whether they were primed within 3 hours or greater than 3 hours after plasma bonding. Degassing the medium before priming seemed to improve the ability to fill the smaller channels. Two attempts were made for the degassed within 3 hours of plasma bonding because after the first run, it seemed the degassed greater than 3 hours of plasma bonding results were better. Upon the second attempt, the results seem to be about equal.