PDMS Microfluidic Chip Commissioning

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Abstract

We plasma-bonded punched PDMS replicas to glass slides, inserted polyethylene tubing into the inlets and outlets, and sealed the interfaces using Anycubic High Clear resin (provided by Stahlenschutz und Detektortechnologie Labor). This report details our workflow and observations for robust leak-free connections.

1 Introduction

In this final lab session, we did the complete PDMS–glass chip assembly workflow: plasma treatment and bonding, then tubing insertion, and resin sealing. This report documents the followed protocol and observed leak-free performance under simple water-flow test. Using an oxygen plasma cleaner and Anycubic High Clear resin, we demonstrated robust Si–O–Si bonding and secure tubing interfaces.

2 Materials & Methods

2.1 Plasma Bonding

After punching inlet and outlet holes, the PDMS replica and a clean glass slide were placed in a plasma cleaner. The two surfaces that will be bonded together have to face up, to be treated by the plasma. The necessary equipment is listed below:

- Oxygen plasma cleaner (Tergeo, pie scientific; fig. 1 (left))
- Water vapor plasma (Tergeo, pie scientific; fig. 1 (right))
- Hot plate for bond strengthening.

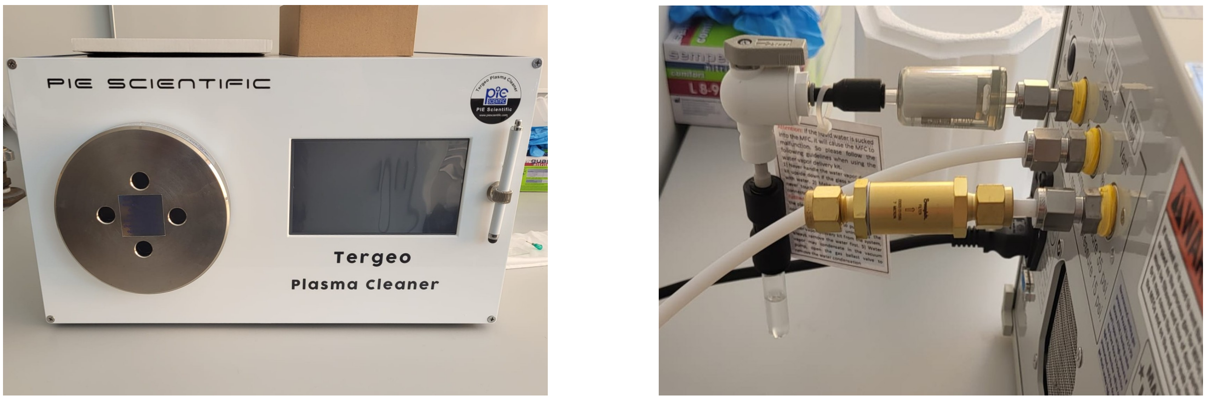

Figure 1: Tergeo, pie scientific: Plasma Cleaner (left) and water vapor adapter (right) [1].

Immediately after exposure, the surfaces were brought into contact and held under light pressure to ensure full-area adhesion. Air bubbles that are trapped between the surfaces are gently squeezed outside. The bonded assembly was then baked at 70 °C for 10-30min to strengthen the Si–O–Si bonds and stabilize the seal [2].

The water vapor plasma is necessary to control the humidity inside the camber. If there aren't enough water molecules the plasma can't create the needed amount of OH* functional groups. A high density of OH* hydroxyl functional group on surface improves bonding strength and reliability [2].

2.2 Tubing Insertion

The inlet/outlet ports were create using a 1 mm biopsy punch. Therefor the Polyethylene tubing was chosen with a fitting Diameters (OD,ID). Using tweezers the tip of the tubing was carefully aligned and then gently pushed into the punched holes with controlled force. If successful the Tubing should fit tightly and exit the chip vertically. This can be verified visually and with a careful pull. Below are the required materials:

- Polyethylene tubing, with fitting outer/inner diameters.
- Fine-tip tweezers.

2.3 Resin Sealing & UV Curing

Anycubic High Clear resin (provided by the SDT-lab) was used for gluing the tubing to the PDMS chip. The resin was applied around each tubing-PDMS connection. To limit the amount of resin that is used a small pipette tip is used to only apply the necessary amount around the connection. Then the region was exposed to UV light with a uniform wavelength of 405 nm. After about a minute of exposure the resin is cured and the connection should be sealed. Below is a list of the required equipment:

- Anycubic High Clear resin (sponsored by SDT-lab) [3].
- UV lamp and Curing station for curing.
- Pipette tip for resin application.

3 Results & Observations

All stages of the assembly workflow proceeded smoothly, although some students had some self-cause issues in the bonding process. Figure 2 shows the completely assembled Chip. A water filled syringe is used to test the chip for any leaks. A dispensing needle adapter is put on the syringe and then inserted into the inlet tube. Carefully applying pressure lets the user see how the chip starts to fill with water. Using a dye, one could make the process of detecting leaks more efficient. Otherwise one can only verify that everything that enters the circuit also leaves it through the outlet.

To summarize the results: the preparation in all previous Lab courses resulted in a final functional microfluidic chip. The bond is uniform and no delamination is noticeable, except from some small air bubbles that were still trapped between PDMS and glass. The Tubing was successfully sealed with resin and no leakage was observed.

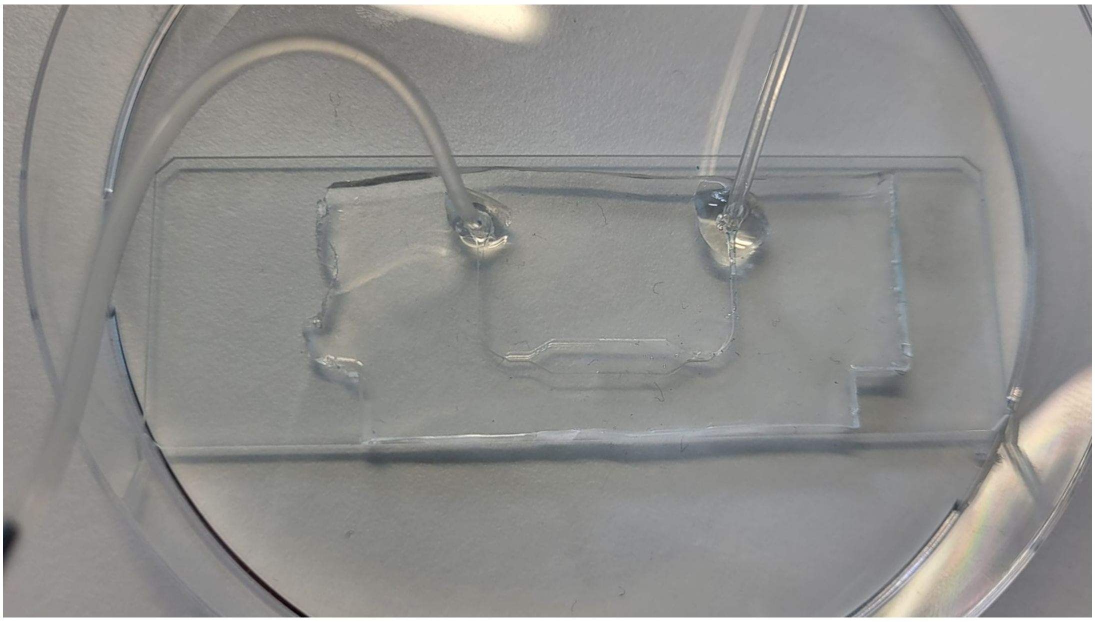

Figure 2: Completely assembled microfluidic chip (halfway full with water).

4 Discussion & Conclusion

The end-to-end assembly protocol (from plasma bonding through resin-sealed tubing insertion) proved robust and reproducible. Plasma bonding produced uniform, irreversible PDMS–glass adhesion. Only on one chip a small air bubble remained, but it did not compromise the seal. Controlled insertion of PE tubing using tweezers and resin sealing cured under UV light reliably prevented any water leakage during syringe-driven flow tests.

Minor user-handling issues highlighted the importance of following the protocol and a necessary understanding of the fabrication process. Overall, this workflow delivers functional, leak-proof microfluidic chips with minimal specialized equipment, laying a solid foundation for future more advanced chips.

References

[1] Pie Scientific, "Tergeo Plasma Cleaner," Pie Scientific. [Online]. Available: `https://piescientific.com/tergeo_plasma_cleaner/`. Accessed: July 20, 2025.

[2] Prof. X. Li, "Lecture on Microfluidics and Lab-on-Chip," *Fraunhofer IMM & HSRM*, 2025

[3] Anycubic, "High Clear Resin," Anycubic Germany. [Online]. Available: `https://de.anycubic.com/products/high-clear-resin`. Accessed: July 20, 2025.