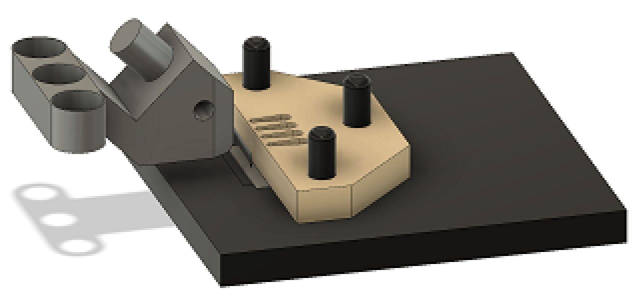
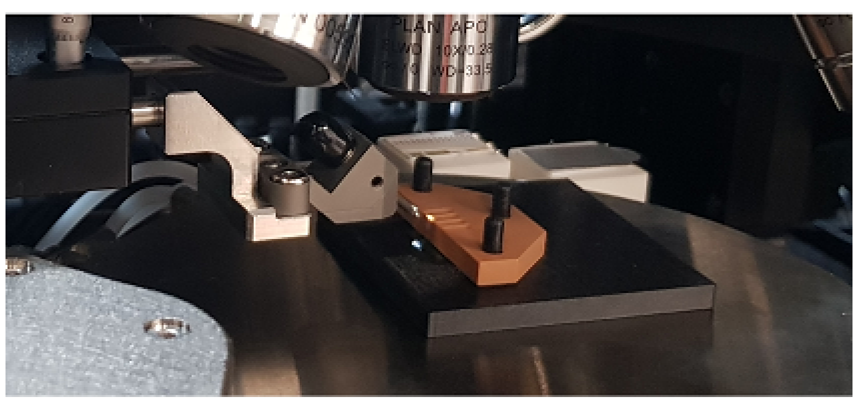
Design of flow cell for resonator measurements in liquid environment

Timothy Loayza





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1 Introduction

The goal of this project was to design a flow cell in order to test micrometer size resonators in a liquid environment. The resonators are piezoelectric actuators with a size in the range of $4[\mu m]$ to $100[\mu m]$, with connection rails of length in order of a few $100[\mu m]$ and with connection pads in the order of a $100[\mu m]$ (Figure 1).

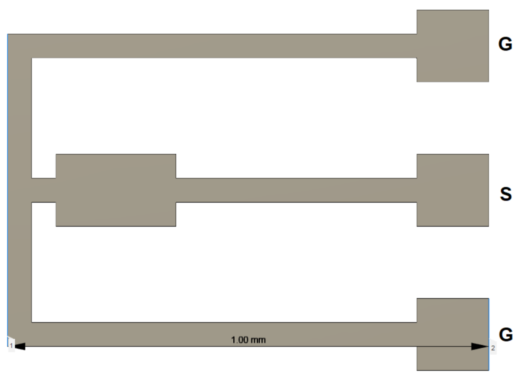

Figure 1: Diagram of the geometry of the resonators.

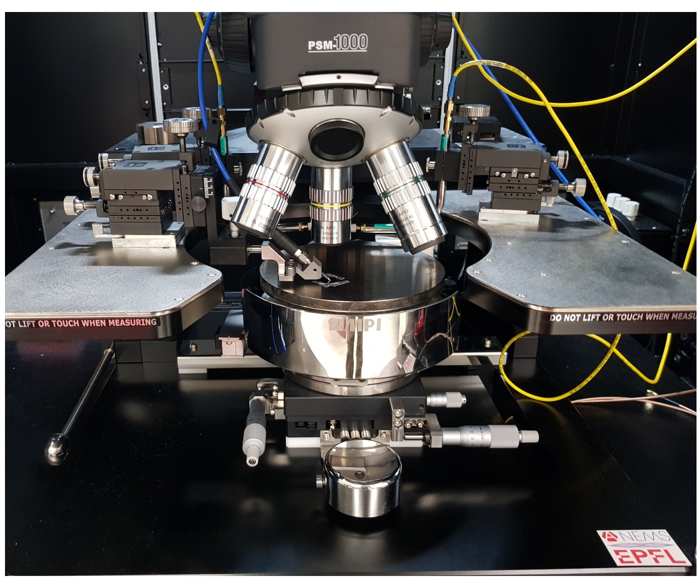

Figure 2: Measurement setup.

Currently measures on the resonators are done with a GSG probe in a measuring setup (Figure 2) without the possibility to immerse the resonator. The measuring setup possessed :

- A GSG probe with a precise positioning mechanical system.
- A microscope to visualize the position of the probe on the connecting pads.
- A stainless steel plate to place the chip.

Thus, the goal of this project was either to create an independent measuring setup or to provide a mean to immerse the resonator while doing the measurement with the existing one (Figure 2).

2 Solution's concept and associated problems

During this project several designs were created but they can be group in two different concepts :

1. a full measuring setup with integrated probes.
2. a system providing the liquid management but using the existing measuring setup to contact the pads.

Another particularity of these system was that they were 3D printed. The flow cells were done in resin (RC 70), to ensure the sealing of the channels and to obtain the required resolution in the order of $100[\mu m]$. The support was done with Fused Deposition Modelling and a later version was enhanced with metallic parts (threads and pins) to better the positioning.

2.1 Stand alone system

This was the first studied type of solution, the stand alone systems that integrated a probe as well as the flow cell on a support. These systems had the benefit to be portable.

2.1.1 Associated problems

The main problem of these systems were to guarantee the tolerances for the contacting of the pads with the probes, as a margin in the order of $100[\mu m]$ was needed and the incertitude on the size and the geometry of the probes gave margins of $500[\mu m]$ at minimum.

2.2 Solely fluid system

This type of solution was the one that was developed and preferred during the project. This is because of the possibility to adjust the position of the probe to contact the pads precisely and with the help of a microscope.

2.2.1 Associated problems

The problem with this solution was the necessity to look at the different components (resonators, pads and probe) to verify the connections with the microscope. This constraint imposed restrictions on the geometry of the flow cell.

3 Iterations and discussion

In this section the different designs that were developed during this project are being presented and reviewed.

3.1 Stand alone systems

In this section two kind of probes were used in the designs. First, the standard MPI T26A probes with a vertical system of fixation (Figure 3). This configuration had multiple problems, only four resonators could be measured on a chip and the probe could not be moved horizontally. Also the z position of the probe would have been difficult to evaluate and would have required a microscope.

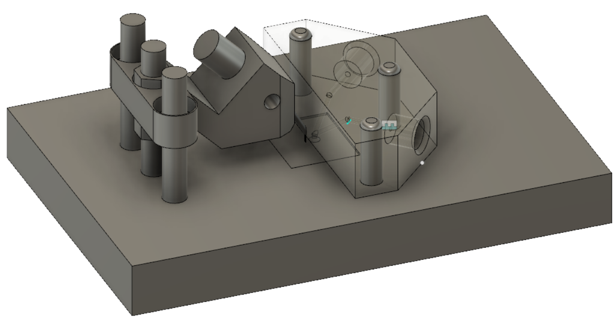

Figure 3: Measurement setup with MPI probe on a vertical axis.

Second, pogo probes associated with a PCB base would have been an option (Figure 4, 5) and it could have been possible to measure several resonators on the chip. The main problems with this configuration were the tolerance of the fixation of the probes on the PCB and the difficulty to check if the contact was done.

The PCB could have placed on the top of the flow cell (Figure 4) which would have allow a better alignment as the same poles for the cell were used for the PCB or on the support base (Figure 5), which would have shortened the length of the probes.

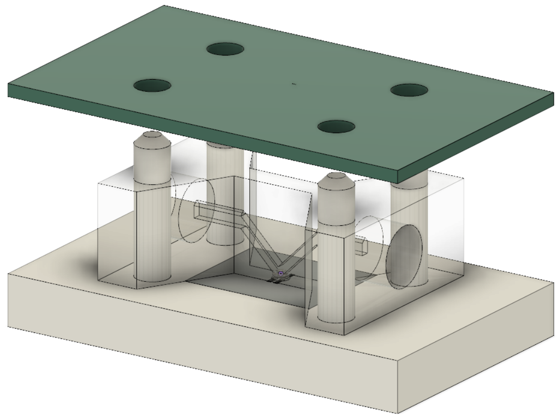

Figure 4: Measurement setup with a PCB on the top of the flow cell.

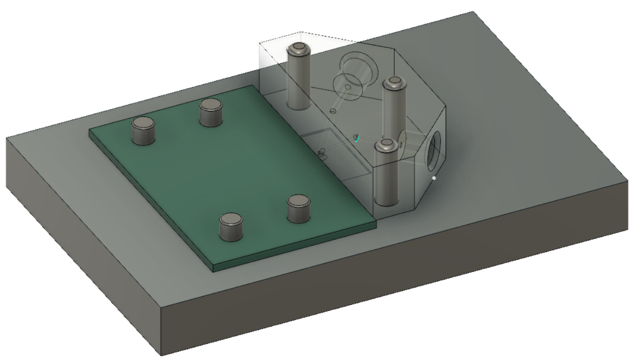

Figure 5: Measurement setup with a PCB on the support base.

3.2 Solely fluid system

In this section, the system using the measuring setup described above (Figure 2) is being presented and how it evolved. Two main concepts emerged :

1. A system with a flow cell allowing the connection of channels and measurements with flows.

2. A system with only holes to pipette liquid directly to the resonator.

both concepts evolved during the project and the evolution was mainly marked by the shape of the flow cell. First the shape was allowing the measurement on both sides of the chip (Figure 6), but this idea was quickly abandoned as it was preferable to turn the chip instead on the support, which gave the second generation's shape (Figure 7).

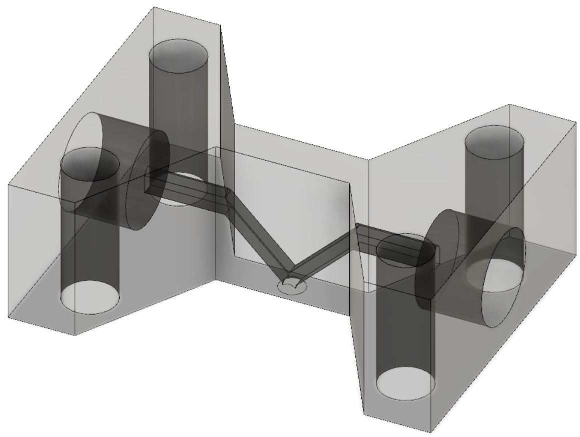

Figure 6: Flow cell of the first generation allowing the measurement on both sides.

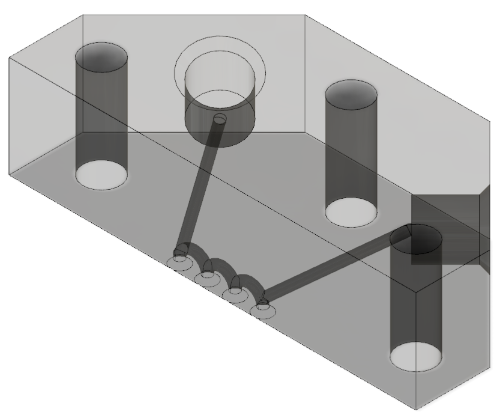

Figure 7: Flow cell of the second generation allowing the measurement on one side only.

This second generation also included four places for O-rings and was the one done in the AFA at the EPFL (Figure 8, 9).

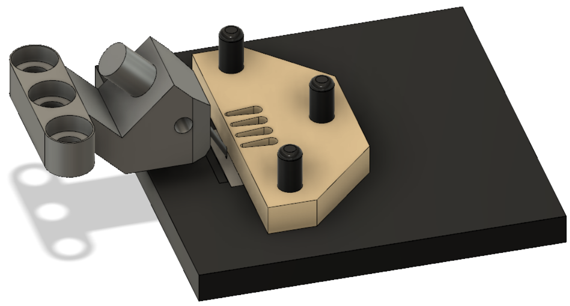

Figure 8: Model of the printed flow cell for pipetting.

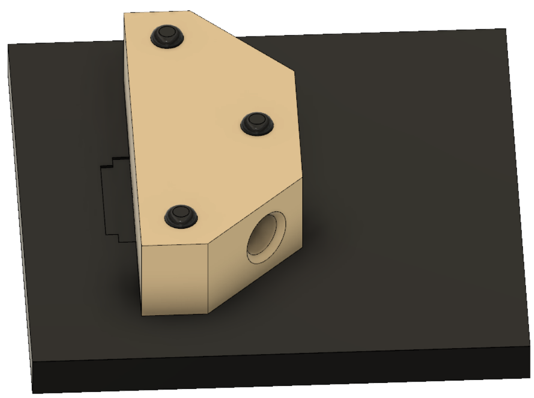

Figure 9: Model of the printed flow cell for measurements with flows.

3.3 Confronting to reality

After the production and during the testing phase several points emerged. Unfortunately the testing on the final chips was not possible but an alternative chip was used. Thus, a few changes had to be done :

1. A possibility to tighten the flow cell to the support plate was needed while still having two positioning pillars, which gave a new support. (Figure 10)
2. The wetting of the chip was not ensured, thus two channels had to enter one O-ring, one to bring the liquid and one to get it and the air out (Figure 11).

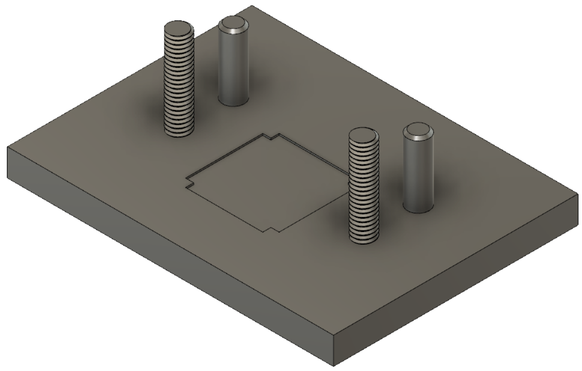

Figure 10: Model of the new support including two threads to screw the flow cell on the chip.

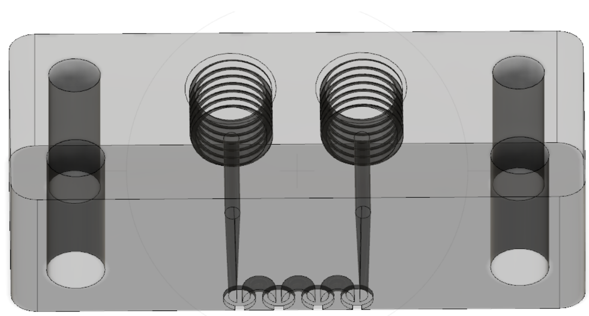

Figure 11: Flow cell including in and out channels for each O-ring.

Even if the designs needed a few changes, the proof of concept was verified, as the liquid was transported successfully in the flow cells and the tests in the measurement setup proved possible to precisely manipulate the probe and place it on the chip (Figure 12, 13).

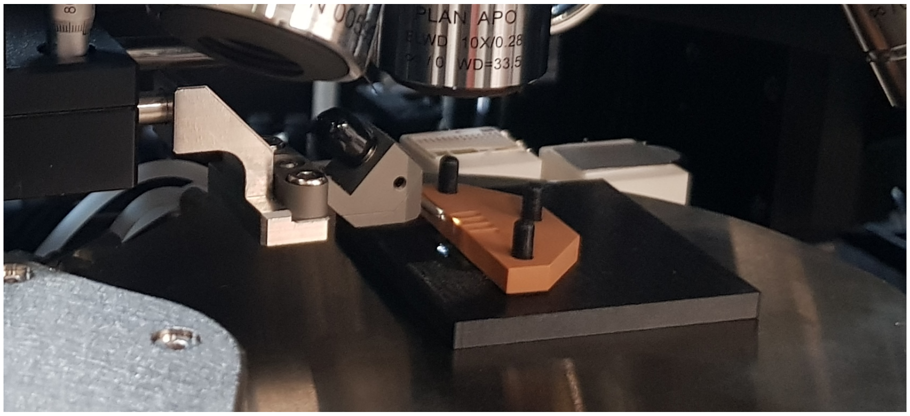

Figure 12: Picture of the test of the pipetting cell in the measurement setup.

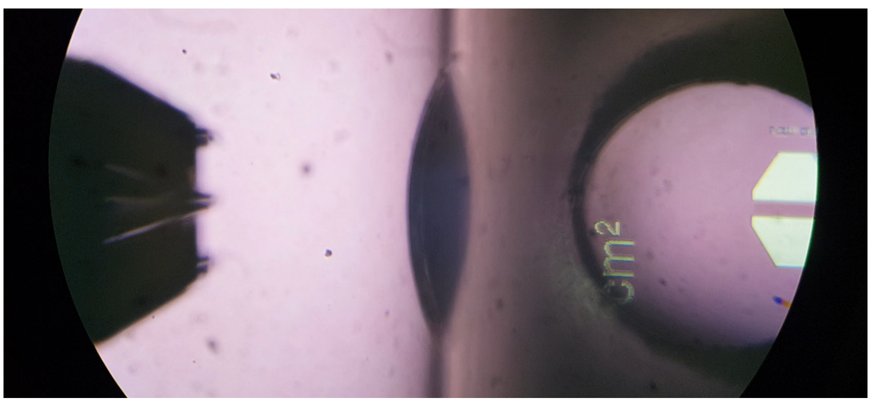

Figure 13: Microscope image of the probe (to the left), being getting near the pipetting cell. Also, the microscope could see in the channel to verify the alignment with the resonator (to the right).

3.4 Final design

Finally, the changes were done on a final version, unfortunately as the AFA closed during the month of June, the new system could not be printed for this report. These new designs include the new flow cells (Figure 14, 15) and the new support (Figure 10).

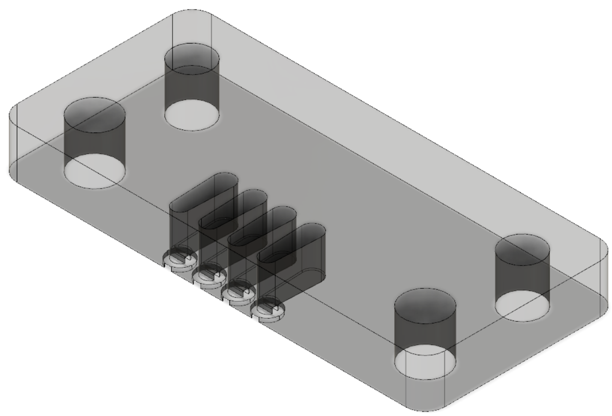

Figure 14: Final design of the pipetting cell.

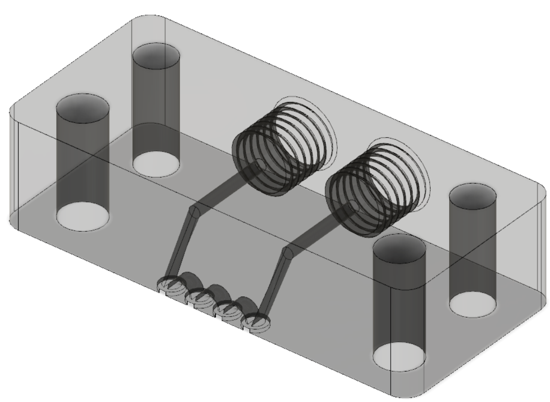

Figure 15: Final design of the flow cell.

4 Conclusion

In conclusion, the goal of this project is near to be reach and could substantially lower the price and the complexity of the measurements of resonators in liquid. This is achieved with the technology of Stereo Lithography with Digital Light Processing that allow a resolution of $70[\mu m]$, an easy design, a price of ten to fifteen francs per flow cell and a lead time of fabrication in the order of a week which is an important reduction compared to traditional machining.

In my opinion, this field of research should be extended because it could potentially enhance the ease of the interfacing of MEMS, which is a crucial problem for the microtechnology industry. As well as the access to cheaper and more personalized devices in the order of the millimeter and tenth of millimeter.

5 Acknowledgment

I would like to thank professor Villanueva for this opportunity to work on this project, his follow ups and advises. As well as to thank Ms. Leghziel for her excellent supervision and her honest opinion all along this project.