Design of a tool for clamping a membrane onto a microwell chip

Lucas Pronk

This Bachelor Assignment was commissioned by VyCAP, a biotech company specialized in the imaging, enumeration, analysis and isolation of rare cells such as Circulating Tumor Cells (CTCs). Currently they are expanding their current product portfolio with a new product line that enables users to analyse the secretion (production) of proteins of individual cells. For this, a product is being developed that clamps a paper based membrane to a VyCAP microwell chip (figure 1).

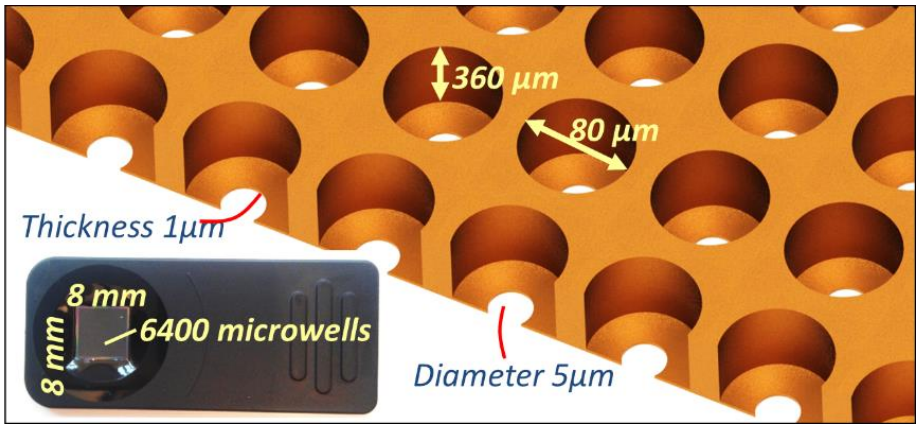

Figure 1: Microwell chip

The microwell chip is filled with cells. Because of how the microwell chip is designed, each cell enters another well, as illustrated in figure 2. When a labelled membrane is clamped to the underside of the microwell chip, the membrane captures the proteins produced by the single cells. These proteins can then be further analysed (figure 3).

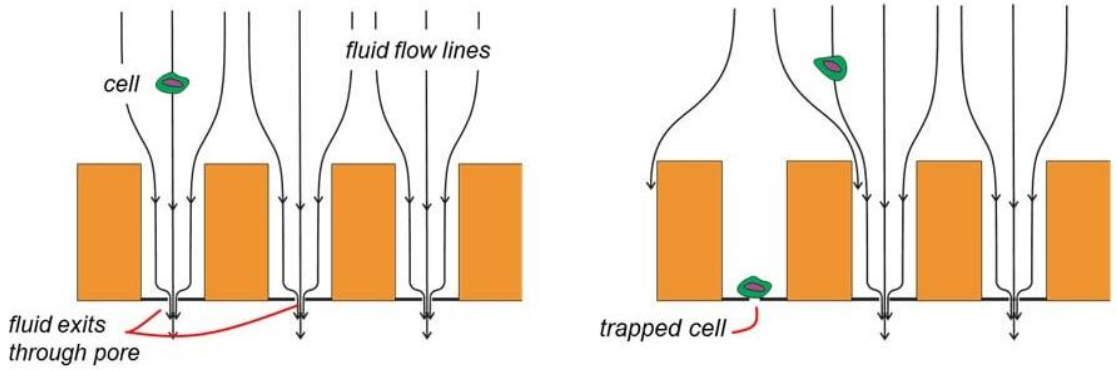

Figure 2: Seeding of single cells in the microwell chip

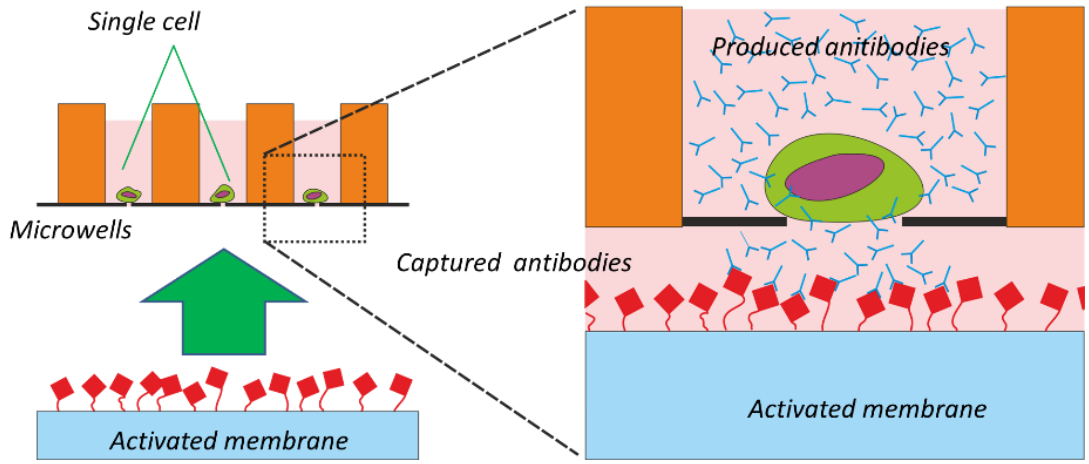

Figure 3: Schematic of membrane mounted on the bottom of the microwell chip

The clamping of the membrane onto the microwell chip is currently done with a clamping prototype, as shown in figure 4. This prototype was developed by VyCAP as proof of concept for capturing molecules on a membrane.

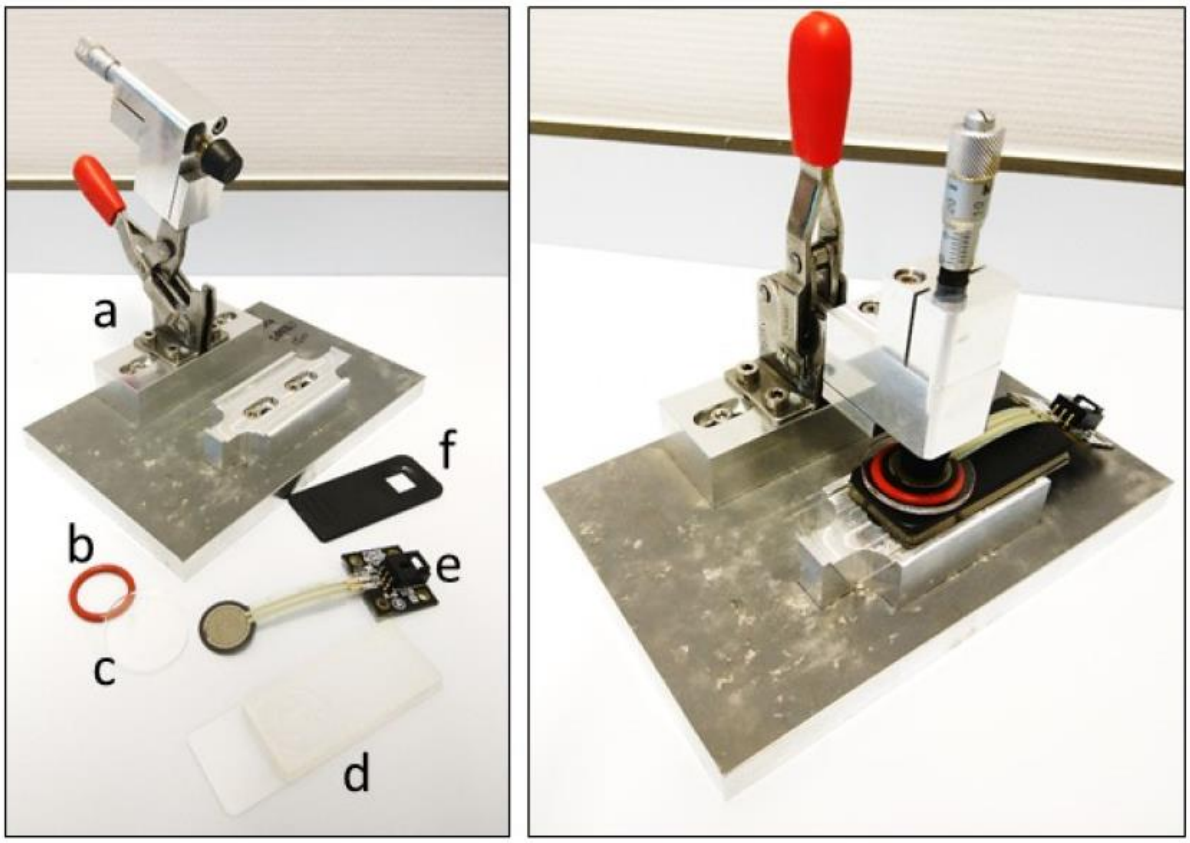

Figure 4: Working prototype of clamping a membrane onto the microwell chip.
a: clamping prototype, b: rubber O-ring, c: cover glass, d: glass plate and PDMS Units, e: force sensor, f: microwell chip.

The target of this Bachelor Assignment was to further develop this tool, and to deliver a prototype which is nearly ready for production. For the development of this tool, designs that were developed prior to this assignment were evaluated and redesigned. These two previously developed prototypes (figure 5), the Box Unit and Plate Unit, were tested. Within this assignment the strength and

weaknesses of these models were evaluated. One of the weaknesses of these two models was improper clamping of the membrane against the bottom of the microwells. In the Box Unit prototype this led to leakage that was probably caused by too much friction on the moving inner components. This prevented the membrane to move far enough up against the microwell chip. The improper clamping in the Plate Unit resulted in unequally capturing of produced proteins across the microwell chip. This was either caused by an unevenly distributed force across the membrane or a force from the spring that is too small.

Figure 5: The two previously developed prototypes: the Box Unit (left) and Plate Unit (right)

Based on the evaluation and observed strengths and weaknesses several new designs and ideas were generated. Each new design was evaluated and adapted accordingly. Some of the improvements where made by combining several parts and changing the parts that require interaction. This reduced production costs and improved the user experience.

Additive manufacturing was used for most prototypes to get a better feeling for the prototype, its size and its operation. The final deliverable (figure 5) is a small, elegant prototype as a new design for the clamping tool. The design follows the color scheme and characteristics from the current portfolio of VyCAP. However, some sacrifices to the styling had to be made to accommodate for functionality. The fourth iteration has two strips on the top for stacking, which are not pleasing to the eye.

A large improvement in the effectiveness of the interaction between the user and the prototypes has been made. There were difficulties with understanding the Box Unit and Plate Unit. Within the design process and evaluation of the new prototypes, proper user interface was found. The user test with the final design of this assignment showed that the user was able to use the prototype intuitively.

The newly designed prototype meets most requirements and wishes, but it is not yet ready for production. More cellular tests need to be performed to find out if it functions the same consistently. Multiple springs with different forces were tested during this assignment to determine which spring resulted in proper clamping. However, each spring was only tested once or twice. To find proper, reliable results, multiple tests with a smaller selection of springs must be performed with the final deliverable.

Some recommendations have been included to improve the prototype and to get it ready for production. These recommendations are different ways to control the gas exchange and membrane alignment, but also the opportunity to combine the device with another product to add functionality.

Figure 5: Render of the final deliverable