CD-Fluidics Team: Blood Plasma Separation on a Reciprocating Microfluidics Disk

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Overview: Current methods of blood testing can be a multi-step process that require expensive lab equipment. The CD-Fluidics team is working on a cheaper, more efficient way of blood testing based upon the design of a CD.

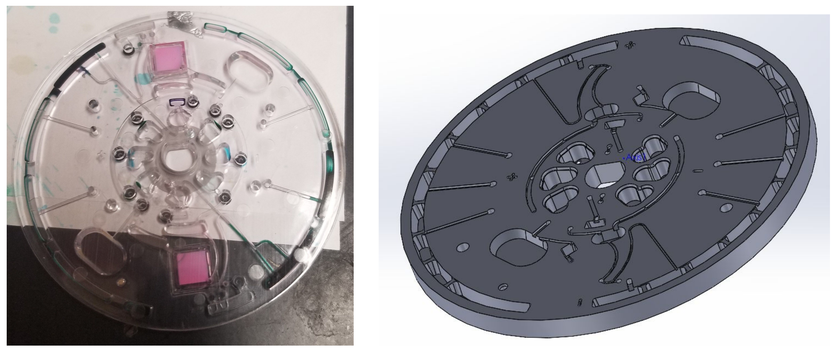

Figure 1: Current disk design

Objective: Our role in this project is to combine the blood separation and testing steps into one process so that the design may be simplified.

Method: Design a valve that will trap red blood cells in a designated chamber soon after the blood enters the testing chamber.

Challenges: After separating the red blood cells, the reciprocation process required for the testing of the blood can cause red blood cells to re-enter the testing chamber. To prevent this we have to consider:

- Euler's force due to changes in disk rotation speed
- Sedimentation of the red blood cells
- Forces of air pressure caused by air trapped in the system

Solutions: To contain red blood cells in their designated chamber

- Decreasing capillary diameter creates greater surface tension
- Chamber depth utilizes blood sedimentation due to gravity
- Capillary slopes limit flow in one direction and utilize blood sedimentation
- Air vent prevents air from becoming trapped and creating air pressure that would push red blood cells out

Design Criteria

Volume	Must hold 30 µl
Containment	Red & White blood cells cannot must not interfere with the testing process
CNC Limitation	Capillaries > 1/64 in
Chambers	Red and white blood cell containment chamber must hold at least 45% total volume
Final Testing Chamber	9.1mm x 9.1mm

Analysis: Volume Calculations (30 µL)
Chamber volume equation: V = b^2 (1mm)
Chamber 1: 30 µL = b^2 (1mm) -> b = 5.5 mm
Chamber 2: 16.5 µL = b^2 (1mm) -> b = 4.06 mm -> 4.125 mm
Chamber 3: 13.5 µL = b^2 (1mm) -> b = 3.67 mm -> 3.75 mm
(for figure 3 design +.35mm for capillary depth)

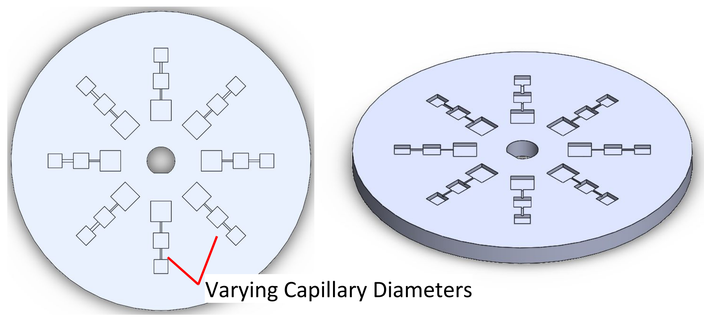

Figure 2: Design with varying capillary diameters

- Capillary diameters begin at 0.40 mm and increase by 0.05 mm
- Goal is to see whether the flow of red and white blood cells can be restricted by capillary size

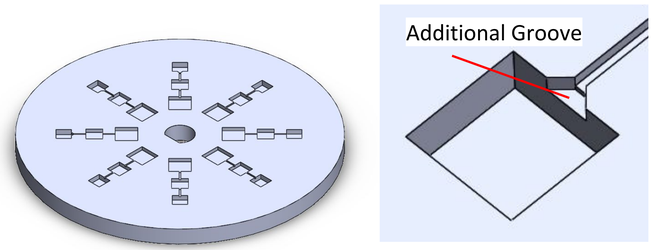

Figure 3: Design with increased chamber depth

- Final chamber on the CD is set deeper (1.35mm depth) to hold the red and white blood cells after initial centrifugation

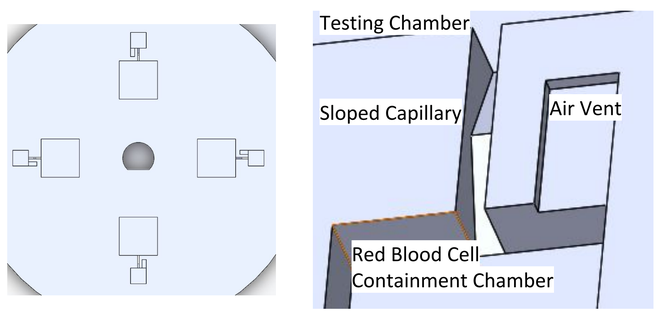

Figure 4: Design with varying capillary slopes

Discussion:

- Physical barriers (wax) were already tested
- Current Goal: See if it is possible to completely bypass the use of a physical barrier

Figure 5: Testing of the Wax Chamber

- Future improvements:
  - Implement the use of a vacuum (tesla valve)
  - Incorporate hydrophobic valve (to prevent leakage)

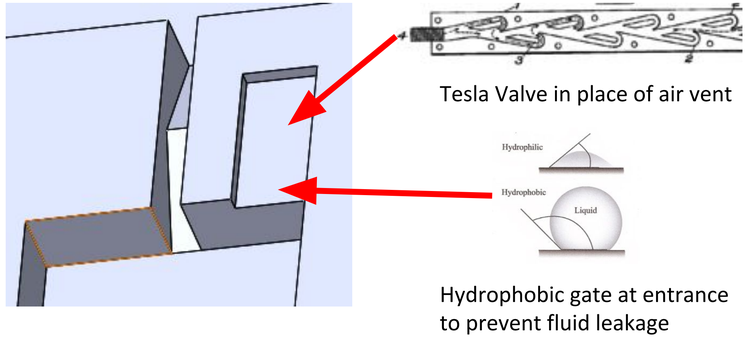

Figure 6: Design of chamber utilizing vacuum

- Applications of CD technology
  - Quick and accurate testing of antibodies
  - Allows for rapid testing for COVID-19 antibodies in patient blood samples

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References:

Noroozi, Z., Kido, H., Peytavi, R., Nakajima-Sasaki, R., Jasinskas, A., Micic, M., . . . Madou, M. (1970, January 01). A multiplexed immunoassay system based upon reciprocating centrifugal microfluidics. Retrieved December 07, 2020, from https://aip.scitation.org/doi/full/10.1063/1.3597578