ABSTRACT

Asta Fluidics is a local startup developing an automated diagnostic test for Fetomaternal Hemorrhage (FMH). FMH is a treatable condition caused by severe fetal blood loss that often results in retardation, cerebral palsy, or death. Asta hopes to become the standard of care in FMH testing and eliminate over 15,000 cases of severe FMH annually in the United States.

The goal of this project was to design a proof-of-concept microfluidic chip for cell analyses, and a chuck to interface between the chip and an electronic reader. Polystyrene beads were substituted for blood to reduce health risks during testing.

Table 1: Critical Project Specifications and Results

<table>
<thead>
<tr>
<th>Specification</th>
<th>Target Value</th>
<th>Achieved (over trials)</th>
<th>Units</th>
<th>Result</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Beads in Display region</td>
<td>&gt; 10,000</td>
<td>44,846</td>
<td>beads</td>
<td>✔</td>
</tr>
<tr>
<td>Filter Efficiency (percent of large particles filtered from solution)</td>
<td>&gt; 90.0</td>
<td>100</td>
<td>%</td>
<td>✔</td>
</tr>
<tr>
<td>Time to 10,000 beads in display area</td>
<td>&lt; 3,600</td>
<td>7.1</td>
<td>seconds</td>
<td>✔</td>
</tr>
<tr>
<td>Accuracy of chip placement</td>
<td>+/- 0.5</td>
<td>+/- 0.1</td>
<td>mm</td>
<td>✔</td>
</tr>
</tbody>
</table>

DESIGN CONSIDERATIONS

Quantifying FMH requires inspection of thousands of red blood cells (RBC’s) from a maternal blood sample. Asta requires a microfluidic chip that samples whole-blood, filters out all large particles, and arranges 10,000 or more RBC’s in the viewing area. Cases of overlapping cells and cells in different focal planes need to be minimized to insure accurate analysis. The precision chuck locates the blood sample under the microscope for consistent viewing.

The chip and chuck are designed to replicate this process by satisfying the key requirements listed in Table 1.

Figure 1: Left: Current FMH Testing Method is Laborious. Right: Asta’s Solution for Quick, Automated Testing

Figure 2: Design Features. Note: Chip Not to Scale
(A) Capillary Action Drives Sample
(B) Pillar Filtration
(C) Bead Trap Array
(D) Chuck Interface

Figure 3: Bead Trap Testing. (10x Objective, Colorized)
Left: Empty Traps Before Sample Insertion
Right: Filled Traps Simulate Cells Ready for Analysis

Figure 5: Chip Fabrication using PDMS Molding

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PROTOTYPING, TESTING, AND RESULTS

Filtration and organization designs were modeled with COMSOL to inform design efforts and demonstrate feasibility. SolidWorks was used to model spring-compression forces on the chip to reduce risk of fracture during insertion.

Figure 4: Left: COMSOL Analysis of Bead Trap Efficiency
Right: SolidWorks Simulation of Cantilever Spring

REFERENCES

1Image Credit: Asta Fluidics