Microfluidic Device

Preliminary Product Design Specifications

Team: Jason Wang
Robert Meuler
Jiacomo Beckman
Nick Pauly
Kevin Koesser

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Function:

The client's lab has designed and constructed several microscope-based instruments for creating 3D nano/microstructure tissue engineered scaffolds. This instrument includes rapid laser shuttering at 10 MHz [1] that results in a network of polymerized protein concentrations that are reflective of grayscale image data. The resulting scaffolds are used for studying cell-extracellular (ECM) interactions in cancers and fibrosis as well as for general biology applications.

Currently, the client's lab procedure for producing these scaffolds is very inefficient in protein usage and human labor. Therefore, our client seeks a microfluidic device capable of washing out the unpolymerized proteins of low volumes ranging between 10 μL to 100 μL. These expensive proteins include collagen, laminin, and fibronectin and should be recollected for re-use. This device will allow a decrease in production time for the engineered scaffolds and decrease cost associated with the experiments. If the device is effectively implemented, it will be used in the client's future research projects.

Client Requirements:

- Compartment(s) that house water and protein solutions such as collagen, laminin, and fibronectin.
- These protein solutions should be filtered and collected separately to be reused in future trials
- Must be compatible with LabVIEW software.
- Must maximize the recovery of the major proteins- fibronectin and laminin take precedence.
- Can be used for other projects.
- Combined budget: $1,500

Design Requirements:

- *Performance Requirements*
    - Maximize the percentage of material recovered.

    - Used over a maximum of 3 hours
    - Reusable for multiple procedures.
    - Parts must be easily interchangeable from wear and tear.
    - Resists protein adsorption over the length of the procedure
    - Needs to withstand the power density of the laser (~1.0 × 10^17 (W/cm^2)) [2].
    - Needs to be compatible with existing LabVIEW framework.
- *Safety*
    - Materials used should be able to withstand the laser without decomposing or affecting the culture.
    - Materials should be compatible with the requirements listed for Biosafety level 2 lab
        - No exotic materials with a risk of causing aerosol-transmitted infections [3]
    - Should not give out an excessive amount of heat that would damage the ECM as well as give off too much light that could affect any experiments.
    - No visible circuitry or moving parts that would affect the user or any other components of the experiment.
- *Accuracy and Reliability*
    - Should recollect greater than 70% of the original sample of proteins
        - Original sample: 45 - 50 μL of solution
        - Concentration of proteins in solution range from 15 - 24%
    - Proteins recovered should be in the same concentration as the original sample
- *Life and Service*
    - Used for 3 hours at a time, on average
    - Used daily
- *Shelf Life*
    - Shelf life should be at least a year
- *Operating Environment*
    - Biosafety Level 2
    - Withstand power density of laser (~1.0 × 10^17 (W/cm^2))
    - No light emission
- *Ergonomics*
    - Used in a controlled laboratory environment (biosafety level 2)
    - Operated by professionals through LabVIEW software
- *Size*
    - Smaller than a regular microscope slide with thickness of 1 mm
    - Similar size to current hybridization chamber currently used in procedure
    - Contain up to 50 μL
- *Weight*

    - Should not exceed .25 kg, which could potentially damage lab microscope
- *Materials*
    - Use materials that are as inert as possible to the conditions of the laser
    - The material should not attract and adsorb proteins.
        - Tests will be done to determine adsorbance of BSA by the materials
        - Tentative materials include SIL-30 and EPU-40 [4]
- *Aesthetics, Appearance, and Finish*
    - Aesthetic must not affect the capabilities of the laser or any other component.
    - Concealed and clean finish

Production Characteristics:

- *Quantity: 1 design*
- *Target Production Cost: less than $1500*
    - Total budget includes purchases made in Fall 2019 semester

Miscellaneous:

- *Standards and Specifications*
    - No human subjects are required for this project, therefore no IRB regulations are required in particular to this assignment.
- *Patient Related Concerns*
    - There are no patients or research subjects that will be directly interacting with this device during use.
- *Competition*
    - Currently, there does not exist a product in the market that exactly meets the needs of our client. There are several components that do exist, such as a microfluidic device powered by a pump [5]. Another component to consider is the microfluidic pump itself [6].

Literature Cited

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[4]Midwestproto.com. (n.d.). *CLIP Materials @ Midwest Prototyping Additive Manufacturing*. [online] Available at: https://www.midwestproto.com/technologies/CLIP-Materials [Accessed 6 Oct. 2019].

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