Microfluidic Gas Diffusion Platform
Product Design Specifications
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Function: The purpose of this device is to create a microfluidic environment in which cells (cardiomyocytes and mesenchymal stem cells) can be cultured and exposed to varying oxygen concentrations, and the reactions of the cells to the various oxygen concentrations can be observed and quantified.

Client Requirements:

1. Device will be a microfluidics system
2. Device should be made using a master device out of SU-8 so multiple devices can be constructed from the master template.
3. Device should be made using poly(dimethylsiloxane) (PDMS) as it is oxygen permeable and widely used as a microfluidics platform material
4. Oxygen concentration in platform should vary from 21% O_2 (ambient concentration at room temperature to 1% O_2.
5. The device needs to incorporate an oxygen detection method to allow for the determination of oxygen concentration at specific points in the cell culture system.
6. All components should be biocompatible with cell culture and non-cytotoxic to cells
7. The design should be as simple as possible.
8. Price range of $500-$1000 for the entire process.

Design Requirements:

1. **Physical and Operational Characteristics**
    a. *Performance Requirements*: The master device template must be reusable for the creation of many devices, each device itself will be used only once for one experiment and contain no bubbles. The device needs to be able to measure oxygen concentration while having no adverse effects on cultured cells.
    b. *Safety*: Production protocols will be followed including all safety requirements. The device itself should be made of materials that are safe for handling under basic laboratory safety procedures. All team members involved in device production will receive chemical safety training.
    c. *Accuracy and Reliability*: The master device needs to reliably allow the creation of each new device to the exact same specifications. This will allow for replicate data to be collected and tested. The oxygen detection system needs to operate within a range of +/-1% oxygen concentration.
    d. *Life in Service*: The life in service of each device will be one experiment lasting no more than two weeks but likely on the scale of three to four hours, the amount of time required for hypoxic conditions to be evident in cardiomyocytes. The master device should last indefinitely until the end of the experiment (up to a few years).
    e. *Shelf Life*: Each device should last after production until it is used. Once in use the device must maintain integrity throughout the entire experiment and not degrade in the presence of standard cell culture media or cells. The master device should last indefinitely.

f. *Operating Environment:* Each device will be maintained in a 37°C, 5% CO_2 dark incubator and will have standard cell culture media (DMEM) inside the device. While culturing, the device will be exposed to 2500 Pa in the gas channels which will diffuse into the device. When cells are being observed they will be placed onto a fluorescent microscope in the dark and exposed to light to cause the oxygen detection system to fluoresce.
g. *Ergonomic*s: The most important aspect of ergonomics is in creating each device from the master template. Each replicate from the master device should be identical to allow it to be used in laboratory experiments.
h. *Size*: Each device should be able to be placed on a standard glass slide (75mm by 25 mm). The cell channels in the device itself should be 250-500μM tall and 250μM-750 μM wide to facilitate cell attachment.
i. *Weight*: The overall weight should not exceed a few grams, but a specific weight of the device is not critical.
j. *Materials*: The master device will be made out of a solid silicone plate with SU-8 cross-linked to its surface. Each device will be made out of PDMS which will be formed to the master device. The PDMS will then be cross-linked to a glass slide. The oxygen detection system will be a ruthenium based thin film. Oxygen detection will be conducted using 3.175mm OD Tygon tubing and a fine gas regulator.
k. *Aesthetics, Appearance, and Finish*: Each device should be made cleanly, but aesthetics is not especially important for this design.

2. Production Characteristics:

a. *Quantity*: One master template. Up to 100 devices created from the master template. One thin film oxygen sensor per device. One set of oxygen tubing and fine gas regulator.
b. *Target Product Cost*: $500-$1000.

3. Miscellaneous:

a. *Standards and Specification*: Each device created from the master template must be identical to all previously made devices. Oxygen dection must be accurate to +/-1% oxygen concentration.
b. *Customer*: Dr. Brenda Ogle and Brian Freeman.
c. *Competition*: Similar designs using oxygen control have been created by the Eddington Lab at the University of Illinois at Chicago, however there is no analogous competition for our specific problem.