Development Oxygen Sensor for Microfluidic Hypoxia Chamber
Product Design Specifications
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Client: *Professor Brenda Ogle, PhD*

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Function:

High accuracy oxygen detection has become a critical step in understanding various physiological effects of hypoxia. The purpose of this project is to test, redesign and produce an oxygen sensor that can be used with the microfluidic-based hypoxia chamber. Previous work on this design project has produced a functioning microfluidic-based hypoxia chamber and preliminary work on the oxygen sensor. This semester will focus on testing the hypoxia chamber, re-examining possible oxygen sensors, and implementing the two systems together. After confirming the hypoxia chamber and oxygen sensor have been assembled properly, the device will be used in experiments involving oxidative stress, ischemia, and reactive oxygen species (ROS)-mediated cellular pathways.

Client Requirements:

- Test the reliability and accuracy of the current preliminary oxygen sensing design using a 48 well plate.
- Improve the system so that it can detect the oxygen concentration from 100% oxygen to 1% oxygen with an accuracy of at least 2%.
- All components of the device must be compatible with the microfluidic device (made with PDMS).
- The device must not have any cytotoxic effects on the cells being cultured, which might be in close contact with the device.
- The sensor may be placed on the top or bottom of the microfluidic device without affecting microscopy.
- The protocol should be easily repeatable and the fabrication should not be time consuming

as new sensors have to be made for each experiment.

Design Requirements:

1. **Physical and Operational Characteristics**
    a. ***Safety**:* The oxygen sensor must be safe for individuals to handle in a laboratory setting. The device must be sterile in accordance with the cell culture protocols that the device will be used with. The materials used should not leak any toxic residue in high temperature situations (such as when autoclaved).

    b. ***Accuracy and Reliability**:* The accuracy and reliability of the sensor will depend greatly on the fluorescent dye and microscope. We are aiming for a less than 2% error rate within each sample and less than 5% variation between samples.

    c. ***Life in Service**:* The device and the oxygen sensor for it are of disposable nature. After each experiment, which can last up to approximately seven days, both the device and the sensor will be disposed of and new ones will be made for the next experiment.

    d. ***Shelf Life**:* Since a device is made as needed, shelf life is not a significant factor in this project. We propose a one month functional storage time.

    e. ***Operating Environment:*** The oxygen sensor should be stable in the incubator (37 C 5% C02). The sensor will be in close contact with and should not be affected by cell culture media, serum, and other chemicals. The sensor should also give a reliable fluorescent signal in a room temperature environment for an hour in order to provide enough time for microscopy.

    f. ***Ergonomics**:* The device should be easy to use by a variety of researchers. It should be small enough to hold in the hand and be simple enough to be operated by inexperienced users.

    g. ***Size**:* The dimension of the sensor should be made according to the dimension of the device so that the sensor can be assembled to the device. The device has a six-inch diameter.

h. ***Weight**:* Weight is not a critical design constraint at this time. The weight of the device should allow it to be carried easily in the hands of the researcher. We aim to keep the mass under 50 grams.

i. ***Materials**:* The materials used should be standard materials used for solid state sensors. Possible materials include fluorescent dye, PDMS, polystyrene and other standard cell culture materials.

j. ***Aesthetics, Appearance and Finish:*** Since the sensor may be placed over the microfluidic device, the sensor area above the culture should be transparent and clear so that microscopy is not affected. The sensor should have sufficient sealing with the microfluidic devices.

2. Production Characteristics

a. ***Quantity**:* There will be one oxygen-detecting unit produced for one micro-hypoxia chamber.

b. ***Target Product Cost**:* The proposed budget for this semester is $500.

3. Miscellaneous

a. ***Standards and Specifications:*** The product is not drug related and does not require any FDA approval. Neither human nor animal testing is required so there are no concerns for approval. The only protocol that the device must adhere to is the mammalian cell standard operation procedures and specifications.

b. ***Customer:*** The device is a custom design for Dr. Brenda Ogle and graduate student Brian Freeman. Eventually, other members of the Ogle lab will be utilizing the device and, if applicable, other labs doing similar research at other institutions.

c. ***Patient-related Concerns:*** The device will be used in a purely research setting so there are minimal concerns regarding patients. There is no patient data or other sensitive information at risk.

d. ***Competition:*** Most of the competing devices are from various other labs and universities and are therefore optimized for their own research projects. The University of Michigan created a well known thin-sensor film which is too expensive for the Ogle Lab. The Microtechnology Medicine Biology Lab at the University of Wisconsin-Madison also created an oxygen sensing system which is not optimized for Dr. Ogle's purposes.