Development of Polymer 'Chips' used in Medical Diagnostics

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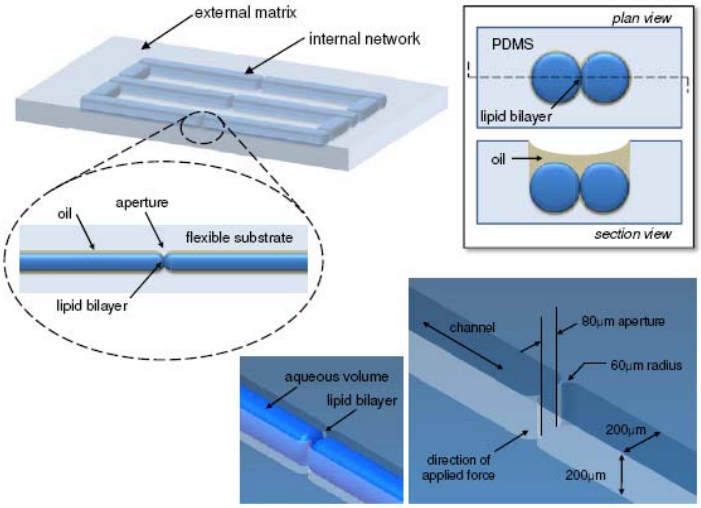
Introduction

Recent interest in biological molecules such as phospholipids, proteins, and ion channels has led to the development of several types of bio-inspired materials and devices, including chemical sensors, rotary motors, and bio-transistors. Proteins and ion channels serve as the active components in many of these devices, and are assembled into an artificial bilayer lipid membrane (BLM). It is the presence of this BLM that gives rise to the sensing and actuation response observed within this new class of bio-inspired active material. One research area that is under investigation is the use of these biomolecules in the development of test methods for medical diagnostic kits. A critical component of this concept is a polymer 'chip' that incorporates test solutions, proteins, and analyte, and is inserted into an electronic reader that performs the measurement.



Project Outline

This project will focus on the design and optimization of the test 'chip' being developed in collaboration with researchers at Virginia Tech. Current designs use simple geometries fabricated from common polymer materials. The chip designs incorporate a micron-sized channel with multiple chambers within a polymer substrate (see figure). The goal of the project will be to develop a new chip design that maintains the critical properties of the standard chip but is an improvement in terms of performance, weight, and costs. The tasks of the project will include:

1. Performing static finite element analysis on a series of chip designs to optimize the geometric and physical properties of the chip under the constraints discussed below.
2. Performing a series of dynamic finite element analysis to understand the vibrational response of the chip to a harmonic excitation.
3. Working with Virginia Tech researchers to fabricate and test the chip using standard static and dynamic analysis techniques.

The constraints of the problem include:

1. The chip must have sufficient stiffness and limited creep properties such that it can remain in a deformed position for extended periods of time (e.g. weeks and months).
2. The chip must be compliant enough to deform under reasonable loads.
3. The geometry of the chip must be designed such that a small harmonic excitation at the boundaries excites a resonant response at specific locations on the chip.
4. The materials and the chip geometry must be chosen to minimize weight and cost.

Project Schedule

This project will be conducted over a nine week period. The expected work is outlined in the following timeline:

Week 1: Safety training and project introduction
Week 2: Literature survey, material studies, and introduction to ABAQUS
Week 3: Static finite element analysis of chip designs
Week 4: Dynamic finite element analysis for harmonic excitation
Week 5: Deliver prototype design to Virginia Tech
Week 6-7: Experimental investigation of the prototype polymer chip
Week 8: Begin write-up, finalize experiments as needed
Week 9: Write up results, prepare IMAC paper and presentation

Suggested Reading

1. Sarles, S.A., Leo, D.J., 2009, "Tailored Current-Voltage Relationships of Droplet-Interface Bilayers Using Biomolecules and External Feedback Control," *Journal of Intelligent Material Systems and Structures*, 20, pp 1233-1247.
2. Sarles, S.A., Leo, D.J., 2010, "Physical Encapsulation of Droplet Interface Bilayers for Durable, Portable Biomolecular Networks," *Lab Chip*, **10**, pp 710-717.
3. Sarles, S.A., Leo, D.J., 2010, "Regulated Attachment Method for Reconstituting Lipid Bilayers of Prescribed Size with Flexible Substrates," *Analytical Chemistry*, **62**(3), pp. 959-966.