Department of Electrical Engineering and Computer Science
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6.777 Design and Fabrication of Microelectromechanical Devices

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DESIGN PROBLEM: Non-Silicon Coulter Counter

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Problem Statement

The goal of this project is to design and model a flow chamber that counts biological particles using inexpensive (non-silicon) materials. Coulter counters are the standard equipment used to count particles and to determine the size of the particles. They operate based on a change in electrical conduction between electrodes due to the presence of particles. You should miniaturize this device in materials other than silicon while maintaining or improving its performance.

Design Specifications

The device must be fabricated in biologically friendly materials other than silicon. In other words, the material on the interior of the device cannot be toxic to cells, and should tolerate variations in pH of the fluid. The device must also be visually transparent, at least on one surface.

The device must be able to handle particles of size ranging from 15 μm to 100 nm in diameter. It should be able to differentiate particles differing in diameter by 10%.

Overview

The design process is described below in terms of several distinct tasks. However, it will be quickly recognized that all these tasks interact. The goal of the team is to delegate tasks and provide communication between tasks so that the final merged device design meets the requirements.

System Design

Survey the literature and decide on the basic architecture of the device. (There should be recent literature on a few silicon devices. Look for pros and cons. You may also want to consult the traditional Coulter counter literature.) Create a lumped model to evaluate the flow and the electrical performance. Design the dimensions of the flow passages and the electrodes. Keep in mind issues concerning fluid stagnation (i.e. in square corners in flow passages).

Device Fabrication

Design a process flow and mask sets. The fabrication techniques available to you include soft lithography, polymer embossing, some standard CMOS fabrication steps (e.g. standard

lithography, and e-beam deposition of metals), but no silicon micromachining. The materials that you might consider include glass (microscope slides), SU-8 (a thick negative resist), PDMS, PMMA, polyimide, etc.

Circuit Design
Design and model the electrical measurement circuit that will be used with the device. Estimate the signal to noise ratio during normal operation. Estimate the sensitivity and speed.

Determine the power input to the device, and whether thermal effects from the electrodes will be an issue.

Packaging
Determine how fluids are delivered to the device, and how the electrical contacts are made. The fluidic packaging should prevent cells from sticking to the walls and should have small dead volumes.

Integrate the design
Iterate to ensure that the device geometry, process sequence, flow characteristics, electrical characteristics, and packaging are compatible with each other and meet the system specifications.