**BIEN 401/501: Mass Transport**

**2025 Project**

This is a team assignment. You may work in teams of 2 students (3 with permission from the teacher).

You are tasked to design, model, fabricate, and verify a 2D microfluidic concentration gradient generator. As discussed through your courses, microfluidic systems are characterized by small Reynolds numbers given the small aspect ratios used. Because of this flow characterization, mixing two fluids can present challenges. Microfluidic concentration gradient generators (CGGs) have been designed and used to generate unique concentration profiles that have many applications. These devices come in various shapes, designs, and my use different fabrication techniques in their development.

This project will be broken into 3 stages: Discovery, Fabrication, and Validation.

**Discovery**

Using examples from the literature to serve as a guide, you will be tasked with designing a CGG that can fit on a microscope slide (roughly 1 inch x 3 inches). Using COMSOL check and optimize your design to get the desired concentration gradient (the uniqueness/complexity of your gradient will factor into your grade). You are encouraged to be creative with your design (but keep in mind how the device will ultimately be fabricated). Through your literature review, note the ways that CGGs are currently used in the microfluidic field and possibly present potential applications where they could be used. A few articles have been provided to help you get started (but you should expand your search beyond the articles provided).

**Fabrication**

When you have settled on a working design, you will build the CGG. The method we will use is xerography; we will cut out the channels in a 150 micron-thick piece of double-sided polyimide tape and sandwich it between two glass microscope slides. Holes will be drilled for connecting inlet and outlet tubes. The process may take multiple attempts as you familiarize yourself with the process and ultimately check your device (and fix any flaws that may materialize during fabrication and testing). Detailed instructions will be provided on how to cut the tape and assemble the device.

**Validation**

Once the device has been fabricated, we will test and validate the device. Using programmable syringe pumps, we will feed two inlet solutions (with one of these solutions containing a dye). Images will be taken of the “test zone” and processed using MATLAB. Using the color dye to create a fading contrast, we can plot the profile based off the intensity of the color dye in the test zone. The shape of the profile measured from the physical device will then be compared to your predicted profile from your computational model developed in COMSOL.

**An important note on academic integrity**

There are many models and model documents out on the internet that one can download. There are models in COMSOL’s application libraries and on their website that will send a user to the model’s final results. Though I encourage you to look at some of these for inspiration or assistance on applying certain conditions, refrain from using one of these models and trying to pass it off as your own. I am very familiar with nearly all of these models, and it will be very easy for me to spot them if one was to come across my screen while grading. If a team of students does submit a model that is later shown to be a direct or (almost direct) download from a website or COMSOL, that team will get a grade of 0 for the entire course and be sent to the appropriate university officials for possibly additional sanctions including but not limited to suspension and/or expulsion.

**Final Report Format**

You will develop a final report detailing your work including your models, fabricated device, and test results. The final report should have appropriate citations and figures (with appropriate labels). The final report should have the following sections:

**Introduction**

Using your literature review, comment on the significance and importance of CGGs in the field of microfluidics. Provide examples of how the technology is currently being used and possible future applications (be sure to cite your sources using IEEE format; you should have at least 6 sources though more is strongly encouraged).

**Model**

Present the COMOSL model for your final device. You may briefly discuss earlier design iterations to support your rationale for selecting the design that you ultimately used. You should provide boundary and initial conditions used in the model and specific dimensions and variables used in your analysis. Your preliminary data (i.e., model results) can be presented here to show the feasibility of your design.

**Methods**

Present the steps used to fabricate and test the device here. This should not be a list of steps, but a summary of what you did. Enough detail should be provided so that an outsider could replicate the device and experiment by reading your instructions.

**Results and Discussions**

Show and discuss your results here. Your results should include an image of the testing zone on your device with the dye fluids flowing through it and any plots generated using MATLAB to quantify or map the gradient. If necessary, figures generated in COMSOL can be brought in to support or compare the performance of the device to the predicted model.

**Conclusions**

Comment on how your device performed compared to your model. If there are differences, offer possible explanations. Comment on whether your device could be useful in some of the applications you presented in the Introduction section or comment on how the fabrication process could be altered to make your device more ideal for those applications.

**Works Cited**

Include list of reference with proper IEEE citation format.

**Appendix: MATLAB Code**

Include a copy of the MATLAB script used to “read” the image file and analyze it.

Be sure to format your paper professionally including page numbers and figure numbers. The final report should have team members’ names on the title page. One individual from the team will upload the final report to Canvas using the provided submission link.

**Rubric**

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| --- | --- |
| **Introduction**   * Presentation of the “problem” that CGG tries to address * Background information on CGGs * Discussion on current and possible future applications of CGGs | **15** |
| **Model**   * Model explained with picture and dimensions * Initial and boundary conditions explained * Plots of concentration profile shown | **25** |
| **Methods**   * Methods used to fabricate the device are presented and easy to follow. * Methods used to test and verify the device’s performance are presented and easy to follow. | **8** |
| **Results/Discussions**   * Results are displayed in accurate and readable figures * Results are explained in adequate detail * Figures have appropriate units, axes, and scales * Significance of results is expressed | **25** |
| **Conclusions + Works Cited**   * Results are summarized adequately * Flaws or shortcomings in the model/device are identified * Significance of model/device and their results are discussed * At least 6 credible sources were used and cited * Appropriate citation format was used | **10** |
| **Appendix: MATLAB program**   * MATLAB program was provided | **7** |
| **Other**   * Spelling, grammar, and punctuation are correct * Paper format is correct (page numbers, figure numbers, etc.) | **10** |